Compton Particles and Quantum Forces

in a holo-fractal universe

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Abstract

An alternative physical model for fundamental particles, fundamental forces & black holes is presented based on classical physics, an unconventional variant of quantum physics as well as holographic & fractal principles whereby the presented model is primarily based on work from Horst Thieme and Nassim Haramein. In this document their models are combined, refined and extended into a joint model that is wider in scope and which also adopts some elements from the work of Randell Mills and Erik Verlinde. The deduced equations produce a good number of interesting results and new understandings which might be perceived as controversial, though, with regard to contemporary physics. The presented content covers a broad range of topics in physics to demonstrate the model's wide applicability and to spark more future research. In particular it is shown that entropy plays an even larger and more fundamental role in physics than currently acknowledged and that the Planck units are more than an arbitrary system of units.

Keywords: Compton wavelength; electron; proton; neutron; muon; tau; photon; hydrogen; quantum; space-time; gravity; special relativity; general relativity; mass; charge; strong force; Planck units; Planck's constant; black hole; Schwarzschild; Kerr; holographic principle; gravitational constant; spin; de Broglie wavelength; Schrödinger equation; uncertainty; electromagnetism; dipole; fractal; dark energy; dark matter; Hubble constant; force unification; entropy; thermodynamics; octahedron; tetrahedron; Platonic solids

1 INTRODUCTION

Reading Horst Thieme's book "Das entzauberte Elektron"** (1) triggered a series of ideas and insights in the author of this document. In particular, that it might be possible to generalize Thieme's electron model, to make it applicable to other fundamental spin $\frac{1}{2}$ particles, and that his electron model could be related to the work of Nassim Haramein.

The internal structure of the electron is still a mystery today and the electron is often even proclaimed to be a point particle with no spatial extent, which even makes the concept of an internal structure moot. Thieme's view is different, though: he models the electron as a spinning sphere composed of elementary dipoles which are polarized by a presumed central charge monopole. In his book Thieme works out the electron's different aspects like radius, rest mass, spin and self energy composition in addition to considering his models conformity with contemporary physics and experimental evidence.

Haramein's paper "Quantum Gravity and the Holographic Mass" (2) elaborates on explaining the proton mass by applying holographic and geometric considerations. Similar to Thieme's approach Haramein uses a fundamental building block which he calls the "Planck Spherical Unit" (abbreviated as PSU) to model the proton. Haramein also promotes an understanding of quantized space-time being the creator & bearer of all things which itself is built from an arrangement of octahedrons and tetrahedrons. Please note that according to this view space is never empty and highly organized. Moreover, black holes are playing a key role in Haramein's conception of space-time since he thinks that they are expressions of the holographic & fractal nature of our universe. Other interesting hypotheses of Haramein are that gravity could be the origin of spin in our universe and that the strong force might be gravitational in nature.

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***"The disenchanted electron"*

In addition to the concepts of Thieme and Haramein aspects from the work of Randell Mills and Erik Verlinde were adopted into this document. The work of Mills has a very broad scope but its core topics are the electron's electric and magnetic field, the properties of their source charge and molecular bonds (4). Notably, the electron model of Mills does not require the use of quantum physics, apart from Planck's constant, as his model relies primarily on the classical electromagnetism equations of Maxwell instead. Although the electron model of Mills is not in full agreement with the particle model presented in this document, several notions were adopted from his work which are related to electromagnetism. The presented material about quantum gravity, on the other hand, is strongly inspired by the entropic gravity conjecture of Erik Verlinde, who has demonstrated that Newtonian gravity can be obtained from black hole thermodynamics (6). As shown in the sections on quantum gravity it turned out that Verlinde's entropic gravity notion is a natural fit for the models which are presented in this document.

Bringing the aforementioned theories together turned out to be a worthwhile endeavour as the distinct theories proved to be related and compatible to some degree, though that was not always outright obvious. Once the connection points were established cross checks allowed narrowing down the possible solutions and missing "puzzle pieces" of one theory were sometimes present in one of the others. In the end the synthesis and extension of the individual theories resulted in an increased scope and understanding, as presented throughout this document. For example, it is repeatedly demonstrated that the Planck units are fundamental quantities of our universe and not just some arbitrary, or merely convenient, system of physical units.

The terms fractal universe and holographic principle will be used often in this document and therefore a short introduction of these terms is given here.
A fractal universe is assumed to express itself at different scales with the same principles and thereby creating unimaginable complexity from a comparatively small set of principles. Presumably, this is the most efficient way to construct a whole universe. An ostensive example for a fractal object is the Russian matryoshka doll - each smaller doll is similar to the larger one that contained it, but they are obviously not identical. The most well-known fractals are probably computer generated visualizations of the so called Mandelbrot set which can be zoomed endlessly, when using appropriate computer software, whereby its self similar nature is exposed in a visually impressive way.

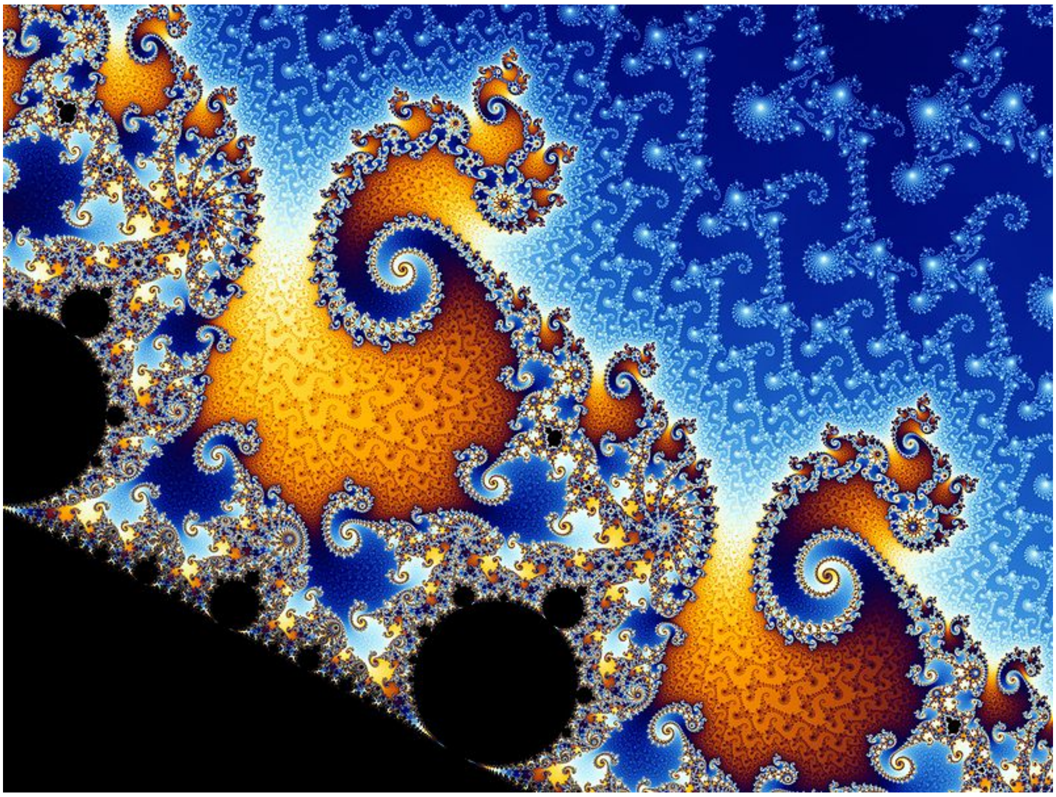

Figure 1: Mandelbrot set visualization*

The holographic principle states that the information contained in a volume of space is also stored on the boundary surface of the given volume whereas the information on the boundary surface is the fundamental one (5). This astonishing principle arose from considerations on black hole thermodynamics and asking what would happen to the information associated with a hot gas that enters a black hole. The assumptions were that this gas cannot leave the black hole, but the associated information must also not be destroyed, and that black holes should also have the maximum possible entropy for their region in space. These conjectures led Bekenstein to the surprising realization that the entropy of a black hole is proportional to its horizon surface and later Hawking continued that work by calculating the exact entropy as well as deriving the associated black hole temperature. These results were subsequently generalized into the holographic principle since any volume of space could turn into a black hole if enough mass enters into it. Consequently, the holographic principle should also apply to our whole universe which implies that the three dimensional reality that we experience might be encoded onto a two dimensional surface that encompasses our universe (in case it is finite). Surface encoding of three dimensional information and perceiving a three dimensional image from a two dimensional surface are actually the key properties of two dimensional holographic pictures and it were these correlations which gave the holographic principle its name.

2 COMPTON PARTICLES

Thieme suggested that electrons are spherical objects which spin so fast that their equatorial ring is moving with light speed (1). He furthermore proposed that electrons are composed of elementary electric dipoles which are attracted and polarized by a central charge monopole, whereby the constituents of each dipole are also assumed to be spherical. The following figure shows a schematic cut-out of the suggested internal electron structure:

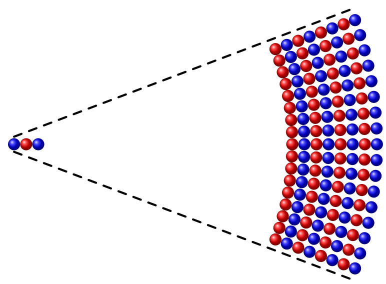

Figure 2: Internal particle polarization

Thieme explained that this structure is similar to what quantum electrodynamics (QED) proposes, but according to Thieme's view the involved minuscule charge carriers are real and not virtual as in QED calculations. Haramein coincidentally uses a similar spherical model for protons whereby a proton's internal structure consists of tiny Planck length sized spheres which Haramein calls Planck Spherical Units, or PSUs for short (2). This similarity was the first hint that the model of Thieme and Haramein might be interconnected. Both models furthermore assume that the conceived constituents of their modelled particle are also the fundamental building blocks of space-time.

Thieme's decision of postulating a maximum surface velocity of light speed c is a sensible choice since it defines a natural particle boundary in space-time which also determines the particle's radius uniquely for each particle specific rotation frequency. This delimitation mechanism can also be regarded as a stall in the quantized space-time medium, caused by the circumstance that the space-time surrounding a spinning particle cannot move faster than light speed, and subsequently the proposed polarization effect must become disconnected at the particle boundary. This thinking is also in line with Haramein, who expressed similar ideas (2), and Randell Mills, whose electron model involves surface currents that move with light speed (4).

Thieme used the aforementioned assumptions together with the Compton wavelength λ_c, which is a renowned quantity of fundamental particles that got determined in numerous photon scattering experiments, to construct a new model of the electron that is strongly anchored in classical mechanics (1). This wavelength is calculated using the frequency $f_p = c/\lambda_c$ that a hypothetical photon must have to possess an energy hf_p which is identical to the rest mass energy mc^2 of a fundamental particle with mass m, i.e. $hf_p = mc^2$. The Compton wavelength is then defined as follows using these relationships, light speed $c = 299\,792\,458\,\mathrm{m/s}$

and Planck's constant $h = 6.626\,070 \times 10^{-34}$ J/Hz:

$$\lambda_c = \frac{h}{mc} \tag{2.1}$$

Contemporary physics claims that the Compton wavelength is a purely quantum physical property with no real expression in classical physics. Thieme, though, rejected this notion and concluded that the reduced Compton wavelength $\lambda_c/(2\pi)$ defines the radius of an unbound electron based on particle spin considerations, which will be presented in section 2.3. The plausibility of this radius will be discussed repeatedly throughout this document, but first the next section will introduce Thieme's model in more detail and also start generalizing it.

2.1 BASIC MODEL

The idea of using the reduced Compton wavelength $\lambda_c/(2\pi)$ as particle radius definition can also be applied to the proton, neutron, muon, positron as well as tau, besides the electron. All of these fundamental particles will be referred to as Compton particles from now on and their radius will be denoted as the Compton radius r_c hereafter.

$$r_c = \frac{\lambda_c}{2\pi} \tag{2.2}$$

Since the circumference of a great circle on a sphere with radius r_c equals $2\pi r_c$, a Compton particle's circumference is equal to its Compton wavelength, which means that the Compton wavelength is a real physical property in the presented model instead of an elusive quantum physical trait.

Assuming a velocity of light speed c at a Compton particle's equatorial ring, and using the circular motion relationship $v = r\omega = 2\pi r f$, gives a characteristic rotation frequency

$$f_c = \frac{c}{2\pi r_c} = \frac{c}{\lambda_c} \tag{2.3}$$

and angular frequency

$$\omega_c = \frac{c}{r_c} = \frac{2\pi c}{\lambda_c} = 2\pi f_c \tag{2.4}$$

for each Compton particle. From now on ω_c will be referred to as angular Compton frequency and f_c as Compton frequency. Please note that the Compton particle model has the following intrinsic relationship between wavelength, frequency and velocity

$$c = \lambda_c f_c \tag{2.5}$$

which coincidentally is also characteristic for electromagnetic radiation in vacuum.

Substituting λ_c in equation 2.1, by using equation 2.5, gives the energy relationship

$$hf_c = mc^2 \tag{2.6}$$

which is structurally identical to the equality $hf_p = mc^2$ that was used for deriving the Compton wavelength λ_c initially - but there is an important difference: the Compton wavelength is a real physical property in the Compton particle model and thus the frequency f_c is also a real physical trait of the respective Compton particle, whereas f_p refers to the frequency of a fictive photon. Equation 2.6 can consequently be used legitimately in the following sections for the calculation of Compton particle properties, as the physical link between Compton frequency and particle mass has been established here.

2.2 PARTICLE PROPERTIES

Using the experimental values for the Compton wavelength, as stated in NIST's CODATA 2014, and the equations from section 2.1 an initial list of Compton particle properties can be calculated from λ_c:

	Proton	**Neutron**
Wavelength λ_c	$1.321\,410 \times 10^{-15}$ m	$1.319\,591 \times 10^{-15}$ m
Radius r_c	$2.103\,089 \times 10^{-16}$ m	$2.100\,194 \times 10^{-16}$ m
Frequency f_c	$2.268\,732 \times 10^{22}$ Hz	$2.271\,859 \times 10^{23}$ Hz
Energy (hf_c)	$1.503\,277 \times 10^{-10}$ J	$1.505\,350 \times 10^{-10}$ J
Mass (hf_c/c^2)	$1.672\,622 \times 10^{-27}$ kg	$1.674\,927 \times 10^{-27}$ kg

	Electron & Positron	Muon	Tau
Wavelength λ_c	$2.426\,310 \times 10^{-12}$ m	$1.173\,444 \times 10^{-14}$ m	$6.977\,87 \times 10^{-16}$ m
Radius r_c	$3.861\,592 \times 10^{-13}$ m	$1.867\,594 \times 10^{-15}$ m	$1.110\,56 \times 10^{-16}$ m
Frequency f_c	$1.235\,590 \times 10^{20}$ Hz	$2.554\,808 \times 10^{22}$ Hz	$4.296\,33 \times 10^{23}$ Hz
Energy (hf_c)	$8.187\,106 \times 10^{-14}$ J	$1.692\,834 \times 10^{-11}$ J	$2.846\,78 \times 10^{-10}$ J
Mass (hf_c/c^2)	$9.109\,384 \times 10^{-31}$ kg	$1.883\,532 \times 10^{-28}$ kg	$3.167\,47 \times 10^{-27}$ kg

Table 1: Compton particle properties

The calculated masses match with the respective experimental value, as expected, but please note that this calculation approach is only valid when assuming that Compton wavelength & frequency are physically real properties. As can be seen from table 1 larger Compton particles have less mass, i.e. the electron is larger in size than the proton but still it possesses less mass, which seems counterintuitive at first but makes sense in the Compton particle model: equation 2.3 and 2.4 show that a particle's rotation frequency decreases with increasing radius and consequently energy & mass are decreasing as they are proportional to a particle's rotation frequency according to equation 2.6. This correlation also leads to a bold speculation: mass as a separate physical property does not exist as it is dependent on a particle's rotation, e.g. a Compton frequency of zero Hertz also implies zero mass, and the upcoming sections will revisit this conjecture to demonstrate that it isn't unfounded. Reflecting on the nature of (mass) energy also supports this conjecture: energy is always associated with translational or rotational motion, or at least with the potential for motion. This insight is as fundamental as the known conservation laws and it should also hold true for the domain of fundamental particles. Viewed from this perspective it is sensible that the mass energy of a Compton particle is connected to some kind of rotational motion.

The calculated radii are certainly a cause of debate. High energy scattering experiments led to the assumption that an electron has minuscule size, or no spatial extend at all, but table 1 states an electron radius that is even bigger than the proton radius. The calculated proton radius is furthermore only 25.0% of the value reported by the latest muon based scattering experiments (8.42×10^{-16} m). These results seemingly invalidate the presented model, but this conclusion is premature because there are several possible causes for these radius oddities:

(a) From black hole physics the phenomenon of frame dragging is known: spinning black holes presumably drag space in their vicinity along. According to the presented model Compton particles are spinning extremely fast and thus frame dragging should also occur in the vicinity of their surface. This possibility will be examined in section 3.13.

(b) The size of a Compton particle may depend on its translational speed. A similar phenomenon, which is called length contraction, is known from the theory of special relativity and section 2.5 will investigate a potential connection.

(c) When modelled as a Compton particle the electron is not a small object relative to atomic scales which leads to some concerns:

   - Collisions of fundamental particles with electrons could be inelastic as a spherical electron might get deformed temporarily during collisions, which would make experimental results difficult to interpret.
   - In his book Thieme cited experimental evidence that scattering experiments of photons with electrons yield different electron sizes depending on the energy of the used photons (1). This result suggests that electrons may be permeable and/or that the size of a photon depends on its frequency.

   Conclusions from scattering experiments involving electrons may thus have to be reconsidered.

And most importantly it will be demonstrated throughout this document that the use of the Compton radius leads to physically sensible results for various calculations.

Comparing the hydrogen radius a_0, which is given by the so called Bohr radius,

$$a_0 = \lambda_{ce}/(2\pi\alpha) = 5.291\,772 \times 10^{-11}\,\text{m} \tag{2.7}$$

with the electron's Compton radius $r_{ce} = \lambda_{ce}/(2\pi)$ reveals that these two radii differ by a factor of $\alpha \cong 1/137$ whereby α denotes the so called fine structure constant or Sommerfeld constant. Thus the relationship of these two radii can be expressed as follows:

$$\alpha a_0 = r_{ce} \tag{2.8}$$

Please note that the electron's Compton radius symbol r_{ce} always refers to a free electron in this document. The radius of an unbound electron is thus smaller by a factor of approximately 137 compared to the radius of

hydrogen. This difference is not unreasonably large as explained in section 2.10, which will examine these relationships in more detail and also discuss the occurrence of α in equation 2.7.
Interestingly the electron's radius r_{ce} also has an α relationship with the so called classical electron radius $r_{cle} = 2.817\,940 \times 10^{-15}$ m as shown in the following equation:

$$\alpha r_{ce} = r_{cle} \tag{2.9}$$

The classical electron radius is only of hypothetical interest, though, since no real physical relevance has ever been found for it. As Thieme pointed out the classical electron radius was derived by assuming too much electrostatic self energy (1) and that the correct electrostatic field energy would have been $\alpha m_e c^2$ whereby m_e denotes the electron's rest mass. The topic of Compton particle self energy will be examined in more detail in section 2.7.

2.3 SPIN & ANGULAR MOMENTUM

According to contemporary physics the spin of fundamental particles is a purely quantum physical property with no real expression in classical physics. It is noteworthy in this context that the Schrödinger equation doesn't predict spin and that its successor, the Dirac equation, is required to get an appropriate quantum physical description for spin $\frac{1}{2}$ particles such as the electron. After publication of the Dirac equation the search for an explanation of particle spin in terms of classical mechanics and angular momentum has mostly ceased, since no classical approach could compute the correct spin.

First the classical angular momentum calculation is reproduced here which led to the rejection of a classical explanation for particle spin. Angular momentum L is given by $J\omega$ whereby J denotes the moment of inertia. In case of a Compton particle the presumed moment of inertia is that of a rigid sphere, which is given by:

$$J_s = \frac{2}{5} m r^2 \tag{2.10}$$

In order to calculate the angular momentum easily all involved terms are rearranged to depend on mass. For the angular Compton frequency this can be achieved by using the general frequency relationship $\omega = 2\pi f$ and $hf_c = mc^2$ (equation 2.6):

$$\omega_c = \frac{mc^2}{\hbar} \tag{2.11}$$

Using equation 2.3 and 2.6 the Compton radius can also be expressed in terms of mass:

$$r_c = \frac{\hbar}{mc} \tag{2.12}$$

Using the last three equations and setting $r = r_c$ the angular momentum of a Compton particles evaluates to:

$$\begin{aligned} L = J_s\,\omega_c &= \frac{2}{5}\,m\,r_c^2\,\frac{m\,c^2}{\hbar} \\ &= \frac{2}{5}\,m^2\,\frac{\hbar^2}{m^2\,c^2} c^2\,\hbar^{-1} \\ &= \frac{2}{5}\,\hbar = 0.4\,\hbar \end{aligned} \tag{2.13}$$

A Compton particle should have a spin of $\hbar/2$ and thus the result of the last equation is not correct, but on the other hand it is already fairly close to the expected result. This suggests that the Compton radius is sensible and that finding the correct result is mainly a matter of using the appropriate moment of inertia.

One initial model assumption was an equatorial ring velocity of light speed c to get a natural particle boundary in space-time. But when a Compton particle is modelled as rigid sphere its surface velocity will decrease towards the poles which might be an undesirable trait. Looking at the work of Randell Mills about electrons which are bound to hydrogen offers a possible remedy for this issue. In his model a bound electron is also spherical but it possesses a superposition of surface currents that move with light speed along great circles (4). The following schematic will make this idea more obvious by depicting two exemplary surface currents.

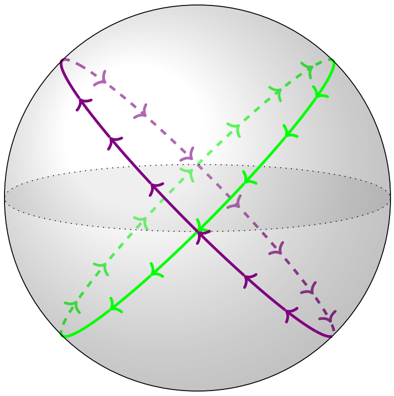

Figure 3: Surface dynamics

In his calculations Mills assumed that the electron's surface is infinitely thin. This is not as inappropriate as it seems since the boundary layer dynamics presumably disconnect the particle's interior from the surrounding space, similar to a black hole horizon.
Thieme proposed that electrons are composed of small spherical charge carriers which also possess mass. Assuming that these individual charge carriers move along great circles, as insinuated in figure 3, implies that their vertical angular momentum contributions cancel out due to symmetry, which only leaves angular momentum components which are parallel to the equatorial plane. As a consequence there is also only a net angular momentum around the particle's spin axis, as it should be, and the spin axis is aligned in parallel with the magnetic moment vector. In that regard the models of Thieme and Mills are compatible.
The appropriate moment of inertia for this dynamical structure seems to be that of an infinitely thin disc, which is given by $mr^2/2$, although that was not proven by Mills based on first principles. Simple symmetry arguments may unfortunately also not enough to prove this moment of inertia assumption. Mills even claims that a free electron, in contrast to an electron which is bound to an atom, is an infinitely thin disc but that notion is not adopted here since it seems unphysical. Thieme also used the said moment of inertia for his electron spin calculations, but he didn't give an explicit justification for its use either. Therefore it can only be professed for now with certainty that using the said moment of inertia produces the correct spin result.

Assuming that a Compton particle's moment of inertia is that of an infinitely thin disc and using equation 2.3, 2.5 as well as 2.6 allows expressing the Compton particle's moment of inertia in terms of various Compton particle quantities:

$$J_c = \frac{1}{2}mr_c^2 = \frac{1}{2}\frac{hf_c}{c^2}\left(\frac{c}{2\pi f_c}\right)^2 = \frac{1}{4\pi}\frac{\hbar}{f_c} = \frac{1}{2}\frac{\hbar}{\omega_c} = \frac{r_c}{2}\frac{\hbar}{c} = \frac{\lambda_c}{4\pi}\frac{\hbar}{c} \tag{2.14}$$

The angular momentum of Compton particles, which is denoted by L_c hereafter, then evaluates to the expected result for spin $\frac{1}{2}$ particles when using J_c as the moment of inertia.

$$L_c = J_c\,\omega_c = \frac{1}{2}\frac{\hbar}{\omega_c}\omega_c = \frac{1}{2}\hbar \tag{2.15}$$

This result applies to every Compton particle irrespective of its radius due to the relationships between the involved Compton particle quantities.

The infinitely thin disc moment of inertia may also be a first hint towards the appropriateness of two dimensional physics, i.e. dimensional reduction, as it may be related to the surface encoding on a holographic boundary. Please note that there may be other current patterns, than the one proposed by Mills, which predict the same moment of inertia. Haramein, for example, proposed a double torus flow pattern which probably is another good candidate for research (*note: see also appendix C*). More information about the current flow topic is given in section 2.10 which examines the electron in the context of hydrogen.

2.4 MAGNETIC MOMENT

For a planar electric current loop the magnitude of magnetic moment M is simply given by AI whereby I denotes the electric current and A the area of the loop. As demonstrated by Thieme this simple formula is sufficient to calculate the electron's magnetic moment since the relevant current is only on the particle's surface. Contributions of dipoles inside a particle's volume are assumed to be irrelevant, either because each electric dipole consists of a positive and negative charge or because the dynamics inside the volume are disconnected from the surrounding space, as already considered in the previous section. In the electron model of Mills also only surface current is relevant because his theory assumes an infinitely thin particle surface. Despite their conceptual differences Thieme and Mills both calculated that the magnetic moment of an unbound electron equals one Bohr Magneton $M_B = e\hbar/(2m_e) = -9.274\,010 \times 10^{-24}$ N m / T (1)(4) whereby m_e denotes the electron's rest mass and $e = -1.602\,177 \times 10^{-19}$ C denotes the electron's charge.

A possible calculation approach is to "slice" the electron surface into small circuit bands and integrating the magnetic moment contributions of all the individual bands. The circumference of a circuit band is given by $2\pi r_{ce} \cos\theta$ where the angle θ is chosen to be $\pm 90\,\mathrm{deg}$ when being parallel to the spin axis and $0\,\mathrm{deg}$ when lying in the equatorial plane. The area enclosed by the band is then given by $\pi r_{ce}^2 (\cos\theta)^2$. The electric charge of a single circuit band is given by charge per area $e/(4\pi r_{ce}^2)$ times the circuit circumference times a small line increment $ds = r_{ce}\, d\theta$. The current of a circuit band is simply given by the Compton frequency times the charge of a single band. Using these presuppositions and the electron's Compton frequency f_{ce} the integral for the electron's magnetic moment is given by:

$$\begin{aligned}
M &= \int_{-\pi/2}^{\pi/2} A \times I \\
M &= \int_{-\pi/2}^{\pi/2} A \times f_{ce} \times \text{ChargePerArea} \times \text{Circumference} \times \mathrm{d}s \\
M &= \int_{-\pi/2}^{\pi/2} \pi r_{ce}^2 (\cos\theta)^2 \times f_{ce} \times \frac{e}{4\pi r_{ce}^2} \times 2\pi r_{ce} \cos\theta \times r_{ce}\, \mathrm{d}\theta \\
M &= \frac{\pi}{2} f_{ce}\, e\, r_{ce}^2 \int_{-\pi/2}^{\pi/2} (\cos\theta)^3\, \mathrm{d}\theta \\
M &= \frac{2\pi}{3} f_{ce}\, e\, r_{ce}^2 \\
M &= \frac{1}{3} \omega_{ce}\, e\, r_{ce}^2
\end{aligned} \tag{2.16}$$

Using equation 2.11 and 2.12 the magnetic moment evaluates to:

$$M = \frac{1}{3} \frac{m_e c^2}{\hbar} e \left(\frac{\hbar}{m_e c}\right)^2 = \frac{2}{3} \frac{e\hbar}{2m_e} = \frac{2}{3} M_B \tag{2.17}$$

This is not the expected result of one Bohr Magneton but the obtained result is also not totally amiss. Thieme actually used several methods to calculate the electron's magnetic moment and also carried out an integration similar to equation 2.16, but it seems that his integral contains an error which resulted in the expected magnetic moment of one Bohr Magneton.

The wrong result of equation 2.17 indicates that it is necessary to consider surface dynamics, like depicted in figure 3, for calculating the electron's magnetic moment. These surface dynamics may be the cause for why the magnetic moment can be calculated by using a single planar current loop approximation, which was presented in Thieme's book (1). Using this approximation and assuming an electric current ef_{ce}, which flows around the electron's equatorial disc area πr_{ce}^2, then allows describing the free electron's magnetic moment as follows:

$$M_e = IA = ef_{ce}\, \pi r_{ce}^2 = e \frac{m_e c^2}{h} \pi \left(\frac{\hbar}{m_e c}\right)^2 = \frac{e\hbar}{2m_e} = \frac{ec^2}{2\omega_{ce}} = M_B = \frac{e}{m_e} L_c \tag{2.18}$$

This result matches the experimental CODATA 2014 value with a deviation of less than 1.2 permil (*note: the remaining error is due to the yet unaccounted anomalous magnetic moment*). Moreover, like in the Compton particle spin case a two dimensional calculation is sufficient for getting the correct result, which again points towards the holographic surface encoding conjecture. Obtaining the correct result for the electron's magnetic moment by using the Compton radius and Compton frequency is also further evidence for their physical meaningfulness. Mills, too, claims a magnetic moment of one Bohr Magneton but his work on the free electron is not fully in line with the presented model since he assumes a disc shaped free electron.

So far the magnetic moment calculation only considered the electron but equation 2.18 can also be generalized to a magnetic moment for Compton particles, which is denoted as M_c hereafter.

$$M_c = \frac{r_c}{2} ec = \frac{\lambda_c}{4\pi} ec = \frac{e\hbar}{2m} = \frac{e}{m} L_c \tag{2.19}$$

Please note that the term ec is characteristic for magnetism (see also equation 4.20) and that it has the physical units of ampere meter. An overview of the absolute magnetic moment for all Compton particles, as predicted by equation 2.19, is given in the following table:

	Magnetic moment M_c	CODATA 2014 value	Deviation
Electron & Positron	$9.274\,01 \times 10^{-24}$ N m/T	$9.284\,76 \times 10^{-24}$ N m/T	1.001159
Proton	$5.050\,78 \times 10^{-27}$ N m/T	$1.410\,61 \times 10^{-26}$ N m/T	2.792854
Neutron (charged)	$5.043\,83 \times 10^{-27}$ N m/T	$9.662\,37 \times 10^{-27}$ N m/T	1.915681
Muon	$4.485\,22 \times 10^{-26}$ N m/T	$4.490\,45 \times 10^{-26}$ N m/T	1.001166
Tau	$2.667\,13 \times 10^{-27}$ N m/T	Unknown	Unknown

Table 2: Magnetic moments

Two things are apparent from the results of table 2: for smaller particles the deviation of calculated to measured magnetic moment is larger and the values in the 'deviation' column are exactly half of the so called g-factor. The proton has the biggest deviation from M_c and the suspected cause is that assumptions which were made for calculating the electron's magnetic moment, in particular the single current loop approximation, are inappropriate for particles who are substantially smaller than the electron, for example due to a different surface curvature. The result for the muon, on the other hand, is remarkably correct although it is considerably smaller in size than the electron.
The difference in the g-factor by 2 seems to be related to the presence of an external magnetic field, like in the Stern-Gerlach experiment, according to Mills (4). This scenario should, for example, cause an electron to align with the external magnetic field vector, in one of two possible orientations, but tilted by $60\,\mathrm{deg}$ due to precession, which explains the missing factor because $cos(\pi/3) = 1/2$. The precessing spin axis of the Bohr Magneton is expected to have an angular momentum of $\hbar$ which then projects onto the magnetic field vector according to $M_B \times (2m/e) \times cos(\pi/3) = \hbar/2$. Therefore it seems that the angular momentum of $\hbar/2$ is creating a magnetic moment that is twice as strong as expected, according to the general relationship $M = e/(2m)L$, when ignoring the tilt angle.
Since the presented model assumes that every Compton particle is internally polarized the magnetic moment of the neutron was also calculated by assuming a surface charge e. Mills proposed that the neutron's surface charge is composed of half positive and half negative charge (4) which may explain why the neutron can have a magnetic moment and still appear as electrically neutral overall.

2.5 DE BROGLIE FREQUENCY

Experiments have shown that fundamental particles exhibit wave like behaviour which is determined by the so called de Broglie wavelength. The non-relativistic formulation of the de Broglie wavelength is given by

$$\lambda_b = \frac{h}{p} = \frac{h}{mv} \quad \text{(for } v \ll c\text{)} \tag{2.20}$$

whereby p denotes a particle's linear momentum mv and v is its velocity. As noted by Thieme the de Broglie wavelength equation is structurally similar to the Compton wavelength equation (1):

$$\lambda_c = \frac{h}{mc} \tag{2.1}$$

Thieme reasoned that both wavelengths might be connected physically and in fact as a particle's velocity increases towards c its de Broglie wavelength tends to the Compton wavelength. This correlation can also be expressed as follows:

$$\frac{\lambda_c}{\lambda_b} = \frac{v}{c} \quad \text{(for } v \ll c\text{)} \tag{2.21}$$

The last equation only applies to non-relativistic speeds, though, because the relativistic formulation of de Broglie wavelength requires relativistic momentum. As a particle approaches light speed its relativistic momentum approaches infinity and subsequently the associated relativistic de Broglie wavelength tends to zero. The consideration of the relativistic case will be continued in more detail below (see equation 2.28).

In the Compton particle model Compton wavelength & frequency are related by

$$c = \lambda_c f_c \tag{2.5}$$

and a similar relationship can be formulated for the de Broglie wavelength

$$c = \lambda_b f_b \tag{2.22}$$

whereby f_b denotes a quantity which will be referred to as the de Broglie frequency hereafter.

$$f_b = \frac{c}{\lambda_b} = \frac{cp}{h} = \frac{mvc}{h} = \frac{v}{\lambda_c} = f_c\frac{v}{c} \quad \text{(for } v \ll c\text{)} \tag{2.23}$$

The reason for introducing the de Broglie frequency is that its non-relativistic as well as relativistic variant, which is stated below in equation 2.29, exhibit a physically sensible value when a particle's velocity is $0\,\mathrm{m/s}$. In this scenario the relativistic de Broglie wavelength has a nonsensical infinite wavelength, whereas the de Broglie frequency equals $0\,\mathrm{Hz}$ in both variants, which is a physically sensible value. This trait suggests that a convincing theory of quantum physics should treat the de Broglie frequency as the physically relevant parameter instead of the de Broglie wavelength, which should rather be regarded as a computational quantity.

There is actually a way to incorporate the aforementioned similarities into the Compton particle model and to give physical meaning to the de Broglie frequency by ascribing it to a Compton particle's second rotation axis. The following figure illustrates this idea by depicting a sphere's two independent rotation axes together with the relevant frequencies.

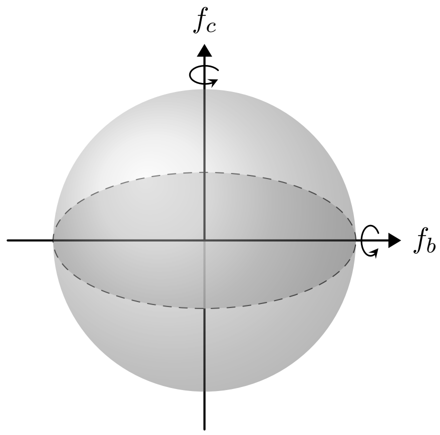

Figure 4: Compton particle frequencies

This idea has a few interesting consequences because in this notion the de Broglie frequency should be responsible for internal energy changes in Compton particles. For example, as a Compton particle's velocity changes its rotational energy changes too, which presumably is met with resistance that manifests itself as translational inertia. On a mechanical level such a change may be linked to an orientation change of the Compton particle's overall angular momentum vector and it is standard physics that such a change is causing physical resistance. Moreover, the presumed internal energy change may also account for a particle's relativistic energy because increasing the de Broglie frequency should become increasingly energy consumptive the higher the de Broglie frequency already is.

A particle in vacuum that is subject to a certain force will experience an inertial counter-force F_i that is proportional to the particle's (inertial) mass m and which limits its acceleration. It will be shown here, for the non-relativistic case, that this inertial counter-force may indeed depend on the de Broglie frequency. The first step is to express linear momentum in terms of the de Broglie frequency and the Compton frequency, which can be achieved by rearranging equation 2.20 and using equation 2.1, 2.21 & 2.23:

$$p = \frac{h}{\lambda_b} = mc\frac{\lambda_c}{\lambda_b} = mc\frac{f_b}{f_c} \tag{2.24}$$

Using the last equation and some standard force relationships then gives the following differential expressions for inertial counter-force with respect to time t:

$$F_i = ma_i = \frac{\mathrm{d}p}{\mathrm{d}t} = h\frac{\mathrm{d}}{\mathrm{d}t}\frac{1}{\lambda_b} = \frac{h}{c}\frac{\mathrm{d}f_b}{\mathrm{d}t} = mc\lambda_c\frac{\mathrm{d}}{\mathrm{d}t}\frac{1}{\lambda_b} = \frac{mc}{f_c}\frac{\mathrm{d}f_b}{\mathrm{d}t} \tag{2.25}$$

The last equation allows extracting expressions for the resulting acceleration a_i which are independent of mass as explicit variable, but dependent on the change of de Broglie frequency or de Broglie wavelength with time instead.

$$a_i = c\lambda_c\frac{\mathrm{d}}{\mathrm{d}t}\frac{1}{\lambda_b} = \lambda_c\frac{\mathrm{d}f_b}{\mathrm{d}t} = \frac{c}{f_c}\frac{\mathrm{d}f_b}{\mathrm{d}t} \tag{2.26}$$

Although equation 2.26 can be expressed in terms of λ_b or f_b the physically relevant process should be the change in de Broglie frequency f_b and the associated change in a particle's internal properties like energy and angular momentum vector orientation. The last equation is also equivalent to $\mathrm{d}v/\mathrm{d}t$, as it should be, since $f_b/f_c = v/c$ (equation 2.23).

Up to here only non-relativistic cases have been treated but examining relativistic particle energy will actually substantiate the presented line of thinking. As known from special relativity theory a particle's relativistic energy can be expressed in the following way:

$$E_\gamma = \sqrt{(\gamma mvc)^2 + (mc^2)^2} \tag{2.27}$$

Here γmv denotes the relativistic momentum and γ is the Lorentz factor $1/\sqrt{1 - v^2/c^2}$. The relativistic de Broglie wavelength, which is denoted here as $\lambda_{b\gamma}$, also involves the Lorentz factor and is given by the expression λ_b/γ. Subsequently the relativistic version of equation 2.21 is given by:

$$\frac{\lambda_c}{\lambda_{b\gamma}} = \gamma \frac{v}{c} \tag{2.28}$$

Using the last equation in equation 2.27 and defining the relativistic de Broglie frequency as

$$f_{b\gamma} = c/\lambda_{b\gamma} = \gamma\, f_b \tag{2.29}$$

then allows expressing the relativistic energy of a Compton particle in terms of wavelengths and frequencies:

$$\begin{aligned} E_\gamma^2 &= \left(mc^2 \frac{\lambda_c}{\lambda_{b\gamma}}\right)^2 + (mc^2)^2 = \left(mc^2 \frac{f_{b\gamma}}{fc}\right)^2 + (mc^2)^2 \\ E_\gamma &= mc^2 \sqrt{1 + \left(\frac{\lambda_c}{\lambda_{b\gamma}}\right)^2} = mc^2 \sqrt{1 + \left(\frac{f_{b\gamma}}{f_c}\right)^2} \end{aligned} \tag{2.30}$$

The $(f_{b\gamma}/f_c)$ term which appears in the last equation can be interpreted as evidence that the Compton frequency and de Broglie frequency have a physical relationship, as asserted before, and that rotational energy is causal for the relativistic energy of a Compton particle.

Comparing equation 2.30 with $E_\gamma = \gamma mc^2$ shows that the Lorentz factor itself can also be expressed in terms of wavelengths and frequencies:

$$\gamma = 1 \Big/ \sqrt{1 - \left(\frac{v}{c}\right)^2} = \sqrt{1 + \left(\frac{\lambda_c}{\lambda_{b\gamma}}\right)^2} = \sqrt{1 + \left(\frac{f_{b\gamma}}{f_c}\right)^2} \tag{2.31}$$

Expressing the Lorentz factor γ in terms of $f_{b\gamma}/f_c$ has the interesting trait that γ can be regarded an intrinsic property of a Compton particle. These new expressions for the Lorentz factor also give interesting expressions for relativistic mass $m_\gamma = \gamma m$ when combined with equation 2.1:

$$\begin{aligned} m_\gamma &= \frac{h}{\lambda_c\, c} \sqrt{1 + \left(\frac{\lambda_c}{\lambda_{b\gamma}}\right)^2} = \frac{h}{c} \sqrt{\frac{1}{(\lambda_c)^2} + \frac{1}{(\lambda_{b\gamma})^2}} \\ &= \frac{hf_c}{c^2} \sqrt{1 + \left(\frac{f_{b\gamma}}{f_c}\right)^2} = \frac{h}{c^2} \sqrt{(f_c)^2 + (f_{b\gamma})^2} \end{aligned} \tag{2.32}$$

Using these new expressions for relativistic mass in the relativistic energy equation $E_\gamma = m_\gamma c^2$ reveals a new frequency term which will be referred to as the Lorentz frequency f_γ hereafter.

$$E_\gamma = ch \sqrt{\frac{1}{(\lambda_c)^2} + \frac{1}{(\lambda_{b\gamma})^2}} = h\, \sqrt{(f_c)^2 + (f_{b\gamma})^2} = hf_\gamma \tag{2.33}$$

$$f_\gamma = c \sqrt{\frac{1}{(\lambda_c)^2} + \frac{1}{(\lambda_{b\gamma})^2}} = \sqrt{(f_c)^2 + (f_{b\gamma})^2} = \frac{m_\gamma c^2}{h} \tag{2.34}$$

The Lorentz frequency is presumably related to a shrinking radius of fast moving Compton particles and the corresponding relativistic radius r_γ is subsequently given by:

$$r_\gamma = \frac{c}{2\pi f_\gamma} = 1 \Big/ \sqrt{\left(\frac{2\pi}{\lambda_c}\right)^2 + \left(\frac{2\pi}{\lambda_{b\gamma}}\right)^2} = \frac{c}{\sqrt{(\omega_c)^2 + (\omega_{b\gamma})^2}} = \frac{\hbar}{m_\gamma c} = \frac{r_c}{\gamma} \tag{2.35}$$

Remarkably, the last equation resembles the so called Lorentz length contraction of special relativity theory, although there is a noteworthy difference: in the presented model a Compton particle will shrink uniformly with increasing velocity whereas special relativity claims that a moving particle only contracts along its direction of motion, which would transform a moving Compton particle into a squashed spheroid.

2.6 SHIELDED CHARGE

Modern quantum physics often uses the concept of short lived virtual particles to explain fundamental fields & the associated forces as well as certain quantum physical phenomena. For example, quantum electrodynamics (QED) postulates that virtual electron-positron pairs created in an electron's vicinity constitute short-lived electric dipoles which modify an electron's electric field as these dipoles become polarized. Coincidentally, it is the Compton radius (equation 2.2) where this polarization effect starts to have significant influence according to QED theory. This coincidence also seems to be contained in the Schrödinger equation as shown in equation 2.59.
In Thieme's electron model, however, the elementary dipoles that constitute the electron are real as well as stable and a central charge monopole is presumably responsible for the polarization of these dipoles (1). The dipole polarization in turn shields the presumed central charge so that the electron's charge as observed from outside the particle is smaller than that of the central charge - which is similar to what QED proposes. Thieme also calculated the magnitude of this central charge in his book (1) and this section will reproduce his calculation.

The electrostatic potential energy U_e for two equal charges q at a distance d is given by

$$U_e = -\frac{q^2}{4\pi\epsilon_0 d} \tag{2.36}$$

whereby $\epsilon_0 = 8.854\,188 \times 10^{-12}\,\text{F/m}$ denotes the electric field constant. Rearranging the last equation for electric charge gives:

$$|q| = \sqrt{4\pi\epsilon_0\, d\, U_e} \tag{2.37}$$

Identifying the electrostatic potential energy at a given distance with regard to the shielded central charges and inserting these values into the last equation will yield the charge of the central monopole. In order to find this shielded charge q_0 the case of an electron positron interaction is examined here. The appropriate distance d is assumed to be the Compton radius of the electron because an electron and positron should have essentially merged at this distance which presumably results in a full depolarization of both particles and the absence of an overall electrostatic field. The next step is to identify the appropriate electrostatic potential energy at that distance. When separating these particles, after they have nearly merged, the particles' internal structure is presumably restored which requires work that should equal their electrostatic potential energy. Thieme calculated that the electrostatic potential energy of an electron makes up 50% of its self energy, i.e. $m_e c^2/2$ (section 2.7 will address the self energy topic in more detail). Hence, the appropriate electrostatic potential energy is 50% of an electron's self energy plus 50% of an positron's self energy, in the outlined scenario, which equals 100% of an electron's self energy. Using this self energy in equation 2.37 and substituting d by the Compton radius (equation 2.12) then gives the magnitude of the shielded central charge q_0:

$$|q_0| = \sqrt{4\pi\epsilon_0\,\frac{\hbar}{m_e c}\,m_e c^2} = \sqrt{4\pi\epsilon_0\hbar c} = \sqrt{2\epsilon_0 hc} = q_l \tag{2.38}$$

Interestingly, the shielded central charge q_0 equals the Planck charge $q_l = 1.875\,546 \times 10^{-18}\,\text{C}$ which is further evidence for the conjecture that the Planck units are fundamental units of our universe and not just some arbitrary quantities.

Thieme stated a different value for the shielded central charge in his book (1), though, namely $\sqrt{\epsilon_0 hc} = q_l/\sqrt{2}$. This result is obtained when, for example, halving the potential energy or the distance which is used in equation 2.38. Further calculations done in this document suggest, however, that the shielded central charge should equal the Planck charge.

Having calculated the shielded electron & positron charge allows comparing it with the elementary charge e:

$$\frac{q_l}{e} = \frac{1}{\sqrt{\alpha}} = 11.706238... \tag{2.39}$$

Interestingly, this ratio contains the square root of the Sommerfeld constant which is regarded as the coupling constant between charge and the electromagnetic field strength (see also section 3.15). Combining equation 2.38 and 2.39 gives the formal definition of this coupling relationship:

$$\alpha = \frac{e^2}{q_l^2} = \frac{e^2}{2\epsilon_0 ch} = \frac{1}{4\pi\epsilon_0}\frac{e^2}{c\hbar} \tag{2.40}$$

Please note that it is the Compton particle model which explains the Sommerfeld constant's meaning, namely through the described shielding effect. In case a Compton particle had one Planck charge, like the shielded central charge or the Planck Spherical Unit (see section 3.1), the Sommerfeld constant's value would consequently be one.

The shielded charge was only calculated for the electron and positron beforehand but it is presumed here that all Compton particles have a Planck charge monopole at their centre which polarizes them - except for the neutron, which is probably polarized in a more complicated way. Evidence for this conjecture comes from the following energy equality which represents the generalized version of equation 2.38 and is obtained by combining equations 2.36, 2.38 and 2.3 (*note: the gravitational counterpart is given by equation 3.31*):

$$\frac{q_l^2}{4\pi\epsilon_0 r_c} = \frac{2\epsilon_0 hc}{4\pi\epsilon_0 r_c} = h\frac{c}{2\pi r_c} = hf_c = E_c \tag{2.41}$$

2.7 SELF ENERGY

Thieme provided calculations for the electron's self energy in his book (1) whereby he identified five different energy contributions which are listed in the following table. The used abbreviations are 'kin.' for kinetic, 'magn.' for magnetic, 'pot.' for potential and 'e.s.' for electrostatic.

Source	Ratio of mc^2	Equation	Type
Spinning mass	$1/4 = 0.25$	$L_c\,\omega_c/2$	kin., mass
Rotating charge	$1/4 = 0.25$	$\phi_e\,ef_c/2$	kin., magn.
Centripetal force	$1/8 = 0.125$	$L_c^2/(2mr_c^2)$	pot., e.s.
Dipole polarization	$1/2.72... = exp(-1)$	$q_l^2/(4\pi\epsilon_0 r_c)\,exp(-1)$	pot., e.s.
External electric field	$1/137... = \alpha$	$e^2/(4\pi\epsilon_0 r_c)$	pot., e.s.
	$1.000177...$		

Table 3: Self energy

The arguments and calculations presented in this section should also apply to other Compton particles, besides the electron, like the positron and muon. Therefore, the equations in this section will always reference general Compton particle quantities, like r_c, even if the accompanying text is referring to the electron. In case of the proton and neutron it is unclear if they have self energy contributions which are identical to the ones of the electron because their magnetic moment is not in accordance with equation 2.19 (see also table 2).

The self energy contributions of table 3 are treated in more detail in the following bullet list:

- **Spinning mass**: This energy contribution simply uses the energy equation for spinning mass which is given by $J\omega^2/2$ whereby J denotes the moment of inertia. Using the angular momentum relationship $L = J\omega$ the energy of a spinning mass can also be stated as $L\omega/2$.
- **Rotating charge**: Thieme used the equation for magnetic energy storage in a planar current loop to calculate the magnetic energy contribution due to rotating surface charge. This approach is similar to the one used for calculating spin and magnetic moment beforehand where a simplified 2D model was used too. Since inductance Υ is related to current I and magnetic flux ϕ by $\Upsilon = \phi/I$ the equation for stored magnetic energy can be stated as follows:

$$E_m = \frac{1}{2}\Upsilon I^2 = \frac{1}{2}\frac{\phi}{I}I^2 = \frac{1}{2}\phi I \tag{2.42}$$

  The magnetic self energy contribution can then be calculated by assuming a current $I = ef_c$ and using the magnetic flux quantum $\phi_e = h/2e = 2.067\,834 \times 10^{-15}$ Wb, which denotes the smallest possible magnetic flux as observed in superconductor experiments. Substituting the aforementioned variables in equation 2.42 gives the magnetic self energy contribution as stated in table 3:

$$\frac{1}{2}\,\phi_e\,ef_c = \frac{1}{2}\frac{h}{2e}ef_c = \frac{hf_c}{4} = \frac{mc^2}{4} \tag{2.43}$$

  Choosing the magnetic flux quantum for this calculation seems to have been an inspired guess by Thieme.
- **Centripetal force**: Thieme reasoned that a centripetal force must hold the dipoles inside a spinning electron together. This centripetal force is presumably caused by the central charge monopole and thus it should be electrostatic in nature. For calculating the associated energy contribution Thieme used the centripetal potential equation $L^2/(2mr^2)$. This equation is derived from orbital mechanics and implicitly assumes a moment of inertia of mr^2 which corresponds to a point mass in circular motion or to a rotating loop - but this moment of inertia is in conflict with equation 2.14 which states that a Compton particle's moment of inertia is given by $mr^2/2$. However, the calculation done by Thieme might be appropriate when considering that the individual dipoles move along great circles as depicted in figure 3 and that Compton particle spin is independent of radius.

- **External electric field**: For calculating this energy contribution Thieme used the electrostatic potential energy equation 2.36 with shielded charge e and distance $d = r_c$. Using an argument similar to the one made in section 2.6 the electrostatic potential energy equation might be appropriate to calculate the energy contained in the electron's external electrostatic field but then this energy should only be 50% of the contribution stated in table 3 since the calculated potential energy is associated with the configuration of two particles (which possess equal charge). An alternative approach is calculating the energy required for assembling a charged spherical shell with charge e and radius r_c which is given by $3/5 \times 1/(4\pi\epsilon_0) \times e^2/r_c$. The result of this approach corresponds to 60% of the external electric field energy as stated in table 3.
- **Dipole polarization**: Thieme stated that dipole polarization should occur inside an electron which is caused by a presumed central charge monopole. Polarizing the dipoles requires energy and Thieme suggested that the potential energy function $+U_0 \frac{a}{r}\, exp(\frac{-a}{r})$ can be used to calculate the associated polarization energy. This function is reminiscent of the Yukawa potential energy function $-U_0 \frac{a}{r}\, exp(\frac{-r}{a})$, but these functions have quite distinct curves and the following figure depicts a visual comparison of them.

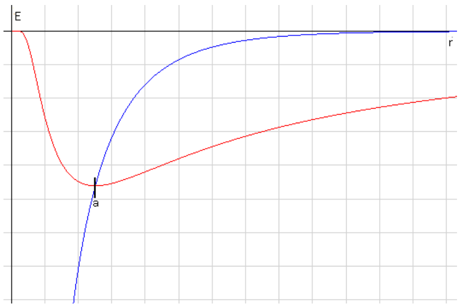

Figure 5: Yukawa potential (blue) & Thieme's potential (red & sign inverted)

To calibrate the potential energy function Thieme assigned the Compton radius to parameter a and for defining U_0 he again used the electrostatic potential energy function. Like in the 'external electric field' case it is not clear if the usage of the electrostatic potential energy is really appropriate and if all of the calculated self energy or half of it should be used for U_0. To get the contribution factor of $exp(-1)$, as cited by Thieme, at radius $r = r_c$ it is necessary to use the Planck charge q_l in this calculation and assigning all of the electrostatic potential energy to U_0 so that U_0 equals $q_l^2/(4\pi\epsilon_0 r_c)$. Please note that using the Planck charge makes sense here since it denotes the shielded electron charge (see section 2.6). Thieme used a charge of $\sqrt{\epsilon_0 hc} = q_l/\sqrt{2}$, though, for the dipole polarization energy calculation which doesn't match his stated result because then the self energy contribution factor for the dipole polarization evaluates to $exp(-1)/2$.

Further insight on the matter of electron self energy is obtained by comparing the magnetic flux quantum ϕ_e to some other quantities. Using equation 4.17 the relationship between the electron's magnetic moment, which is given by the Bohr Magneton (equation 2.18), and the magnetic flux quantum ϕ_e can be expressed as follows

$$\phi_e = \frac{1}{2}\frac{h}{e} = \frac{1}{2}\frac{\mu_0}{\alpha\, r_c} M_c \tag{2.44}$$

whereby $\mu_0 = 4\pi \times 10^{-7}$ N/A^2 denotes the permeability of vacuum. Interestingly the Sommerfeld constant α is also involved in this relationship for reasons which are not fully understood yet.
For comparison the magnetic flux associated with the electron's magnetic moment is calculated next. Therefore the magnetic flux through a disc with area $A = \pi r_c^2$ is determined by assuming a constant magnetic field $B = \mu_0 IN/(2r_c)$ caused by a current $I = ef_c$ that flows in N turns around the disc. Assuming a constant magnetic field is unrealistic for a magnetic field caused by a current loop, and the calculated flux is subsequently underestimated in this case, but for comparison even an approximate result will be useful. Setting $N = 1$ then gives the following magnetic flux:

$$A \times B = \pi r_c^2 \frac{\mu_0 NI}{2r_c} = \pi r_c^2 \frac{\mu_0 e f_c}{2r_c} = \frac{1}{4}\mu_0 e c = \frac{1}{2}\frac{\mu_0}{r_c} M_c = \alpha\, \phi_e \tag{2.45}$$

This result contains two noteworthy points: the calculated magnetic flux is constant and related to the magnetic flux quantum ϕ_e by an unexpected α relationship, which suggests that there is a physical connection between the magnetic flux quantum ϕ_e and the Compton particle model.
There is also an alternative expression of the magnetic self energy contribution: using a different flux in equation 2.42 and using $I = q_l f_c$, instead of ef_c, gives the same result for the rotating charge energy contribution as stated in equation 2.43

$$\frac{1}{2}\phi_l q_l f_c = mc^2/4 \tag{2.46}$$

whereby the flux is now given by the Planck flux ϕ_l:

$$\phi_l = \frac{1}{2}\frac{h}{q_l} = \frac{1}{2}\frac{\mu_0}{\sqrt{\alpha}\, r_c} M_c = \sqrt{\alpha}\phi_e \tag{2.47}$$

This flux can also be obtained by replacing e with q_l in equation 2.45.

It seems that Thieme identified a sensible set of self energy contributions for the electron but it is not clear if the calculations of the individual contributions are already correct as some concerns have been identified above. Moreover, as can be seen in the last row of table 3, the overall self energy is slightly greater than mc^2 and it is the $\alpha + exp(-1)$ contribution that is responsible for the 0.000177 deviation. On the other hand, it is conspicuous that some of the self energy contribution factors have whole number fractions, like 1/4 and 1/8, which suggests that these might be sensible. In case that at least the spinning mass energy and rotating charge energy contributions are stated correctly it is sensible to assume that the total electrostatic contribution factor is $1/2$ of the electron's self energy, whatever the detailed composition of the electrostatic self energy is. Coincidentally, multiplying the electric potential energy equation 2.41 by $1/2$ gives exactly that amount of energy whereby equation 2.41 also features a Planck charge term like equation 2.46. Thus the magnetic and overall electric self energy contribution might also be given by equation 2.46 and 1/2 of equation 2.41 respectively. Please note that multiplying by 1/2 makes sense since equation 2.41 describes the potential electric energy with respect to two Compton particles.

2.8 PLANCK'S CONSTANT

This document often uses Planck's constant h and a number of observations and deductions can be drawn from its appearances:

- Energy terms of the form hf do not only apply to photons but also to Compton particles (see section 2.1) and the following sections will reveal even more applicabilities (see equation 2.69, 3.35 & 4.15).
- Planck's constant h is the fundamental rotation to energy conversion constant of our universe. Therefore the physical units of h should better be stated as $\mathrm{J/s^{-1}}$ or $\mathrm{J/Hz}$ instead of the commonly used $\mathrm{J\,s}$. These three expressions are physically equal but the last one conceals the real physical meaning.
- The units of Planck's constant are identical to the units for angular momentum L, i.e. $\mathrm{kg\,m^2/\,s}$.
- Particle mass cannot exist independently of rotation because in case a Compton particle could stop spinning its mass would become zero (see equation 2.6) and consequently mass should be regarded as an emergent quantity. A Compton particle's fundamental quantities are size, charge and rotation frequency (which is practically synonymous with energy).
- The energy of a Compton particle can be expressed in terms of various quantities which are all related to Planck's constant (see equation 2.3, 2.6, 2.38, 2.41, 2.43, 2.46, 2.47 & 3.31).

$$E_c = mc^2 = hf_c = h\frac{c}{\lambda_c} = h\frac{c}{2\pi r_c} = \frac{q_l^2}{4\pi\epsilon_0 r_c} = \frac{e^2}{4\pi\epsilon_0 \alpha r_c} = 2q_l\phi_l f_c = 2e\phi_e f_c = G\frac{m_l^2}{r_c} \tag{2.48}$$

- All Compton particles share the same ratios of mass, frequency, radius and energy (see equation 2.3 & 2.6):

$$h = \frac{mc^2}{f_c} = \frac{E_c}{f_c} = mc\lambda_c \quad \text{or equivalently} \quad \hbar = \frac{mc^2}{\omega_c} = \frac{E_c}{\omega_c} = mcr_c \tag{2.49}$$

- The term $c/\hbar$ can be used to define a new quantity: the Compton acceleration a_c.

$$\frac{c}{\hbar} = \frac{1}{mr_c} = \frac{c\,\omega_c}{E_c} = \frac{a_c}{E_c} = 2.842\,788 \times 10^{42}\,\frac{\mathrm{m/s^2}}{\mathrm{J}} \cong 2\sqrt{2} \times 10^{42}\,\frac{\mathrm{m/s^2}}{\mathrm{J}} \tag{2.50}$$

  Curiously an approximate $\sqrt{2}$ term is present in equation 2.50 with a deviation from the exact result which is less than 0.51%. This is a relatively large deviation for fundamental physics but curiously more $\sqrt{2}$ relationships appear in other results and fundamental constants which are presented in the sections below.

- Rearranging equation 2.50 for the Compton acceleration a_c gives some further insights.

$$a_c = \frac{c}{\hbar}E_c = c\,\omega_c = \frac{c^2}{r_c} = \frac{c^2}{\lambda_c/2\pi} \tag{2.51}$$

  The circular motion relationship c^2/r_c reveals that the Compton acceleration a_c denotes the centripetal acceleration at the equatorial ring of a Compton particle. Moreover, setting r_c to the Planck length l_l results in the so called Planck acceleration $a_l = c^2/\,l_l = 5.560\,816 \times 10^{51}\,\mathrm{m/s^2}$.

- The term $c/\hbar$ (equation 2.50) is a fundamental scaling factor for energy to acceleration which appears in gravitational acceleration when expressed in terms of energy (see equation 3.73) and in Compton particle energy when expressed in terms of acceleration (see equation 2.51 or 4.8).
- The term $\hbar/c$ appears in the fundamental mass equations 2.12, 3.7 & 3.15 because of the mass to energy relationship $m = E_c/c^2 = \hbar/(cr_c)$.
- See section 4.1 for the meaning of the term $c\hbar$ which is linked to the unification of electromagnetic and gravitational force.
- All of the self energy related equations in table 3 can be transformed into hf_c terms as shown by the following equations:

$$L_c\,\omega_c/2 = hf_c/4 \quad \text{(using equations 2.4 \& 2.15)} \tag{2.52}$$

$$L_c^2/(2mr_c^2) = \frac{1}{2}\frac{\hbar^2}{4}\frac{c^2}{hf_c}\frac{2^2\pi^2 f_c^2}{c^2} = hf_c/8 \quad \text{(using equations 2.6, 2.15 \& 2.3)} \tag{2.53}$$

$$q_l^2/(4\pi\epsilon_0 r_c)\,exp(-1) = hf_c\,exp(-1) \quad \text{(using equation 2.41)} \tag{2.54}$$

$$e^2/(4\pi\epsilon_0 r_c) = hf_c\,\alpha \quad \text{(using equations 2.41 \& 2.40)} \tag{2.55}$$

The rotating charge energy contribution was already expressed as hf_c term in equation 2.43. Being able to transform all these self energy contributions into hf_c terms suggests that all of them are fundamentally linked to a Compton particle's rotation - even the electrostatic energy contributions.

2.9 SCHRÖDINGER EQUATION - PART ONE

This section will examine the Schrödinger equation in the Compton particle context, by examining its time independent variant, which is given by:

$$\frac{d^2\psi}{dx^2} + \frac{2m}{\hbar^2}[E_{tot} - E_{pot}(x)]\psi = 0 \tag{2.56}$$

Using equation 2.1 and 2.6 the term $2m/\hbar^2$ can be reformulated in terms of Compton wavelength, Compton frequency and Compton radius:

$$\frac{2m}{\hbar^2} = \frac{8\pi^2 m}{\lambda_c^2 m^2 c^2} = 2\left(\frac{2\pi}{\lambda_c}\right)^2 \frac{1}{hf_c} = 2\frac{1}{r_c^2}\frac{1}{hf_c} \tag{2.57}$$

Inserting equation 2.57 into 2.56 leads to the following variants of the Schrödinger equation:

$$\frac{d^2\psi}{dx^2} + 2\left(\frac{2\pi}{\lambda_c}\right)^2 \frac{E_{tot} - E_{pot}(x)}{hf_c}\psi = 0 \tag{2.58}$$

$$\frac{d^2\psi}{dx^2} + 2\frac{1}{r_c^2}\frac{E_{tot} - E_{pot}(x)}{hf_c}\psi = 0 \tag{2.59}$$

Solutions to the Schrödinger equation supposedly describe particle location probabilities which makes these two new variants more sensible than the original formulation: the energy term $E_{tot} - E_{pot}(x) = E_{kin}(x)$ is now divided by $hf_c = mc^2$ which results in a dimensionless energy scaling term, mass m as explicit variable has vanished and other than that only sensible geometric variables remain like λ_c and r_c. Interestingly the $\hbar^2$ term, which doesn't have a sensible physical meaning, has vanished too. Moreover, being able to incorporate characteristic Compton particle model quantities into the Schrödinger equation naturally also supports the Compton particle perspective on fundamental particles.

There is also one more noteworthy variant of the Schrödinger equation which features a $c\hbar$ term, whose meaning for fundamental forces is examined in section 4.1. Using equation 2.49 the $\hbar^2$ term can be replaced by $\hbar mcr_c$ in equation 2.56 which then gives the following neat variant of the time independent Schrödinger equation that also features the Compton radius:

$$\frac{d^2\psi}{dx^2} + 2\frac{1}{c\hbar}\frac{1}{r_c}[E_{tot} - E_{pot}(x)]\psi = 0 \tag{2.60}$$

Please note that the $c\hbar$ term also appears in gravitational and electromagnetic force equations after reformulating them (see equation 3.28, 4.11 and 4.20 or appendix A).

This first attempt of combining the Compton particle model with the the Schrödinger equation seems promising but two severe conceptual issues remain:

1. The Compton particle model treats particles as spheres with definite spatial properties whereas the Schrödinger equation supposedly describes particles in terms of waves and position probabilities. This constitutes another expression of the well known particle/wave duality problem of quantum physics.

2. Exited states of an electron that is bound to a proton do not exhibit spherical symmetry according to solutions of the Schrödinger equation, but the Compton particle model can only deal with spherical particles.

There are at least three possible approaches to resolve issue one. The first is adopting the so called pilot wave theory which was originally proposed by David Bohm (14). The second is choosing/finding another interpretation for the Schrödinger equation which does not involve positional probabilities. Mills, for example, thinks that a probability based interpretation of quantum physics is improper and he substantiates his thinking by explaining the famous double slit experiment in a different way. According to Mills the material of which the two slits are made interacts electromagnetically with incoming particles so that currents which are induced in the material lead to an electromagnetic interaction that produces the observed interference pattern on a screen behind the slits. Mills also provides a detailed description in his book (4) and a more illustrative explanation is available on a website of his company Brilliant Light Power*. The third way for resolving issue one is probably the most compelling one as it fits conceptually with the content that is presented in section 3 of this document. The Compton particle model approves quantum physical uncertainty of position & momentum as a real phenomenon (section 3.16) and Juho Leppäkangas proposes that the Schrödinger equation is a statistical effect resulting from this quantum physical uncertainty in an entropy maximizing manner (17). The charm of this solution is that it also eliminates the so called wave function collapse which is a source of endless confusion and dispute.
Issue two will not be discussed here because a possible solution to it is proposed in the following section.

2.10 HYDROGEN

Only free Compton particles have been treated beforehand and this section will make a first attempt at evaluating how Compton particles can form atoms by examining the simplest atom: hydrogen. Thieme suggested that hydrogen forms when an electron absorbs a proton into its centre to form a compound particle (1) which implies that Compton particles are considered to be penetrable objects in the Compton particle model. After combining into hydrogen the electron radius is no longer determined by light speed (see equation 2.4) - instead the electron's radius is determined by the equilibrium between electrostatic attraction to the proton and the centrifugal force. This force equilibrium can be approximated as follows by treating the electron as an object in circular orbit around the proton

$$m_e \frac{v_t^2}{d} = m_e a_e \tag{2.61}$$

whereby m_e denotes electron mass, v_t denotes the electron's tangential velocity, d is the separation distance between proton & electron and a_e denotes the acceleration caused by the electrostatic force which keeps the electron in orbit. Using equation 4.12 to substitute a_e and dividing by electron mass m_e gives:

$$\begin{aligned} \frac{v_t^2}{d} &= \frac{r_{ce} c^2 \alpha}{d^2} \\ v_t^2 &= \frac{r_{ce}}{d} c^2 \alpha \end{aligned} \tag{2.62}$$

The conventional radius of hydrogen in its ground state is given by the so called Bohr radius a_0 (see equation 2.7) which will simply be used here without deriving it as it is confirmed by various experiments. Setting distance d in equation 2.62 to a_0 and using equation 2.8 to substitute r_{ce}/a_0 by α then gives the following equatorial ring velocity for hydrogen:

$$v_{hy} = c\alpha = 2.187\,691 \times 10^6 \text{ m/s} \tag{2.63}$$

This velocity is also known as orbital velocity of the classical Bohr atom model for hydrogen. Thieme and Mills also calculated this velocity with different calculation approaches. Using the equatorial ring velocity v_{hy} the characteristic frequencies for hydrogen in its ground state can be stated as follows

$$\omega_{hy0} = \frac{v_{hy}}{d} = \frac{c\alpha}{r_{ce}/\alpha} = \frac{c}{r_{ce}} \alpha^2 = \omega_{ce}\, \alpha^2 \tag{2.64}$$

$$f_{hy0} = \frac{\omega_{hy0}}{2\pi} = \frac{c}{2\pi r_{ce}} \alpha^2 = f_{ce}\, \alpha^2 \tag{2.65}$$

whereby ω_{ce} denotes the angular Compton frequency of the free electron and f_{ce} denotes the corresponding Compton frequency. Interestingly the last two equations exhibit a $\alpha^2 = 0.0000532514...$ term which is also present in the definition of the so called Rydberg constant

$$R_\infty = \frac{1}{2} \frac{\alpha^2}{\lambda_{ce}} = \frac{1}{4\pi} \frac{\alpha^2}{r_{ce}} = \frac{1}{4\pi} \frac{\alpha}{a_0} \tag{2.66}$$

* http://brilliantlightpower.com/double-slit

whereby λ_{ce} denotes the Compton wavelength of the free electron. Using equations 2.5, 2.64 and 2.65 to substitute λ_{ce} in equation 2.66 the Rydberg constant can also be expressed in terms of hydrogen's frequency:

$$R_\infty = \frac{1}{2}\frac{f_{ce}}{c}\alpha^2 = \frac{1}{2}\frac{f_{hy0}}{c} = \frac{1}{4\pi}\frac{\omega_{hy0}}{c} \tag{2.67}$$

The Rydberg constant can actually be written in many different ways but it is the Compton particle model which provides actual physical meaning to it. As observed by Thieme the α^2 term is related to the difference in properties between a free electron and one bound in hydrogen (1): one α is related to the electron's radius expansion, as stated in equation 2.8, and one α is due to the rotational slowdown, as described by equation 2.63.

Using equation 2.67 hydrogen's potential ground state energy can be expressed in terms of frequency:

$$E_{hy0\_pot} = -2R_\infty hc = -hf_{hy0} = -hf_{ce}\,\alpha^2 = -m_ec^2\alpha^2 \cong -27.2\,\text{eV} \tag{2.68}$$

Please note that expressing hydrogen's potential energy in terms of frequency seems to be novel and again highlights the general relevance of hf terms. For excited states of hydrogen the equatorial ring speed v_{hy} doesn't change with hydrogen's radius which is given by $r_{hy} = a_0\,n^2 = r_{ce}\,n^2/\alpha$ for an orbital number n. Hydrogen's higher energy levels are subsequently defined by $E_{hy\_pot} = -hf_{hy} = E_{hy0\_pot}/n^2$ whereby $f_{hy} = f_{hy0}/n^2 = c\alpha^2/(\lambda_{ce}n^2)$ denotes the associated rotation frequency for an excited state with orbital number n. Hydrogen's potential energy for arbitrary radii can then be stated in the following ways:

$$E_{hy\_pot} = -hf_{hy} = -hf_{ce}\frac{\alpha^2}{n^2} = -m_ec^2\frac{\alpha^2}{n^2} = -\frac{c\hbar}{r_{ce}}\frac{\alpha^2}{n^2} = -\frac{ch}{\lambda_{ce}}\frac{\alpha^2}{n^2} = -\frac{c\hbar\alpha}{r_{hy}} \cong -\frac{27.2\text{eV}}{n^2} \tag{2.69}$$

The same result can be achieved by solving the Schrödinger equation, which is not immediately obvious since the usually stated result $-m_ee^4/(4\epsilon_0^2h^2n^2)$ is somewhat bulky and conceals the relationship to hydrogen's frequency and radius.

The results presented in this section suggest that the Compton particle model is extendable to hydrogen, but there is a serious conceptional conflict remaining which was already mentioned in section 2.9: contemporary physics claims that the electron is point like and that its positional presence probabilities, as predicted by the Schrödinger equation, do not exhibit spherical symmetry for excited hydrogen states. Both of these notions do not fit with the Compton particle model which assumes that a spherical electron, with real spatial extend, absorbs a proton to create the spherical compound particle which is known as hydrogen. Fortunately Mills already provides an interesting solution which may resolve this issue: he proposes a current density function for a spherical electro-magnetic wave that is linked to the Schrödinger equation via a Fourier transformation (4) and which predicts the same energy levels as the Schrödinger equation for hydrogen, but the solution of Mills has the advantage that it fits nicely with the Compton particle model and that it makes physical sense. The following image visualizes both approaches to make the conceptional difference easier to understand:

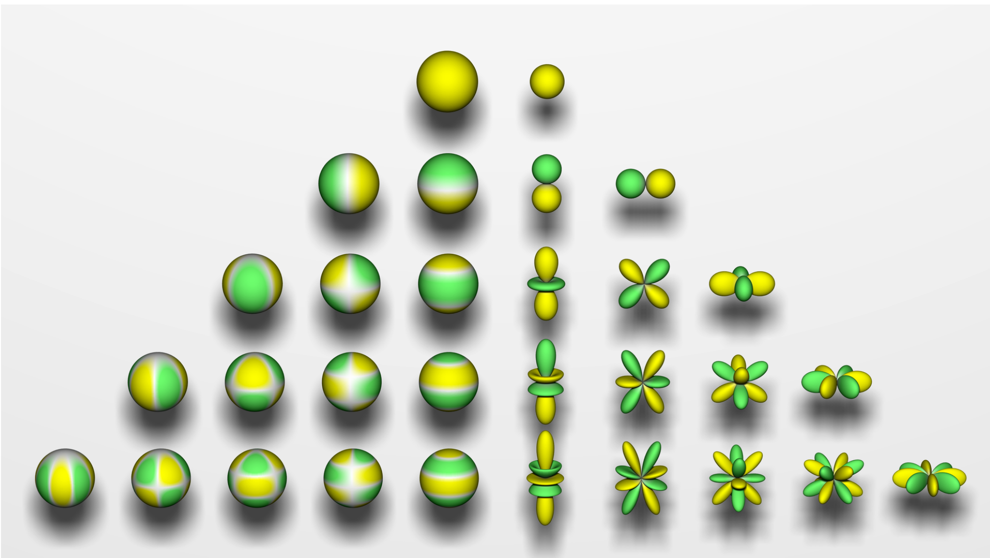

Figure 6: Spherical harmonics, current distributions (left) versus position probabilities (right)*

*Image by Daigokuz. Shared under the creative commons BY-SA 3.0 license. http://commons.wikimedia.org/w/index.php?curid=21482189

According to the conception of Mills an electron remains spherical in excited hydrogen states and the properties that change are radius, rotation frequency and current distribution. The reason why these spherical electrons do not radiate, like other accelerated charges, comes from the fact that the electric current equation which was devised by Mills fulfils the little known electromagnetic non-radiation condition as described by Hermann Haus in (16).

Another sensible prediction of the Compton particle model is that an electron's magnetic moment is not changing when it gets bound to hydrogen. Using equation 2.18 together with the appropriate hydrogen quantities demonstrates that the involved α^2 terms cancel out so that the result is again one Bohr Magneton:

$$ef_{hy0} \times \pi a_0^2 = ef_{ce}\alpha^2 \times \pi r_{ce}^2/\alpha^2 = ef_{ce} \times \pi r_{ce}^2 = M_B \tag{2.70}$$

3 QUANTUM GRAVITY

Haramein introduced a concept called holographic mass in his paper "Quantum Gravity and the Holographic Mass" (2) which will be examined in the sections below. In another paper named "The electron and the holographic mass solution" (3) Haramein et al give a short overview of contemporary science in the field of holographic physics, how this branch of physics has started & developed in the context of black hole thermodynamics as well as how the related papers helped him formulating his concepts. The most influential concept he built on was the so called holographic principle which states that the information inside a certain volume is also simultaneously present on the surface of that volume (5). This principle led him to the conjecture that mass depends on the information ratio of a volume and its enclosing surface. To calculate that quantity for a spherical object Haramein introduced the "Planck Spherical Unit" (PSU) and defined the information ratio as the ratio of the number of PSUs that can be placed on a sphere's surface and inside its volume. Notably, Haramein got sensible results when he applied his holographic mass concept to black holes and protons (2) which is a remarkable achievement because it connects two scientifically distinct domains that defied unification before.

Stongly correlated with the property of mass is the topic of gravitational force and some of Erik Verlinde's work will be presented in the following sections to introduce the notion of emergent gravity. This concept regards gravity as an emergent phenomenon which arises from entropic effects and Verlinde was able to derive Newton's law of universal gravitation from entropic considerations on black holes (6). Another noteworthy conjecture of Verlinde's research is that gravity deviates from Newtonian gravity on galactic scales and should morph from a $1/r^2$ law to a $1/r$ law (7). This transition might explain the rotational motion of galactic discs which currently can only be explained by assuming the presence dark matter. A first experimental survey using weak gravitational lensing showed that Verlinde's emergent gravity theory fits with the collected data but further tests were deemed necessary by the involved researchers (8).

The following sections will also demonstrate that the models of Haramein and Verlinde are interconnected with each other as well as the Compton particle model. Some changes have been made to holographic mass model, though, which will be outlined in more detail below and the content of section 3.8 also gives rise to a reconsideration of the aforementioned information density concept.

3.1 PLANCK SPHERICAL UNIT (PSU)

The PSU as defined by Haramein is spherical, has a radius of one half Planck length and a mass of one Planck mass. This document will also utilize the Planck Spherical Unit (PSU) but the PSU radius is changed to one Planck length for reasons that will become apparent later. Furthermore it is proposed that Haramein's PSUs and Thieme's dipoles are similar entities - Thieme's dipoles presumably consist of two PSUs which also implies that PSUs have a positive or negative charge. The PSU charge is also defined to equal the shielded Compton particle charge for reasons which become apparent in section 4. Expressing these definitions as equations:

$$\text{PSU radius: } l_l = \sqrt{\frac{\hbar G}{c^3}} = 1.616\,23 \times 10^{-35}\,\text{m} \tag{3.1}$$

$$\text{PSU mass: } m_l = \sqrt{\frac{c\hbar}{G}} = 2.176\,47 \times 10^{-8}\,\text{kg} \tag{3.2}$$

$$\text{PSU charge: } \pm q_l = \pm\sqrt{2\epsilon_0 hc} = \pm 1.875\,55 \times 10^{-18}\,\text{C} \tag{2.38}$$

The PSUs are also assumed to be the building blocks of space itself which also implies the polarizability of space. Although individual PSUs possess charge the vacuum is still charge neutral overall because there

should be an equal amount of positively and negatively charged PSUs in space.
On the other hand, a PSU mass of one Planck mass seems to be unreasonable for the smallest building block of our universe and this is probably one of the main reasons why the Planck units are usually considered to constitute an arbitrary system of units. The following sections, though, will demonstrate that this PSU mass is actually sensible and how it fits into the larger picture.

3.2 HOLOGRAPHIC MASS

The following sections will use the same symbols, or at least similar ones, as used by Haramein in "Quantum Gravity and the Holographic Mass" (2) to avoid confusion for readers of both papers. As already mentioned in the previous section the PSU radius which is used here is one Planck length and there are also some differences in proportionality constants that are pointed out later.

The notion of an information ratio was already brought up in the Quantum Gravity introduction section and is now formalized here. The measure of information for a sphere's surface is defined as the surface area of a sphere with radius r divided by the area that a great circle encloses on a PSU:

$$\eta = \frac{4\pi r^2}{\pi l_l^2} = 4\left(\frac{r}{l_l}\right)^2 \tag{3.3}$$

The measure of information for a sphere's volume is defined as the sphere's volume divided by the volume of a PSU:

$$R = \frac{4\pi r^3/3}{4\pi l_l^3/3} = \left(\frac{r}{l_l}\right)^3 \tag{3.4}$$

These measures of information can then be used to define a characteristic information ratio:

$$\phi_h = \frac{1}{4}\frac{\eta}{R} = \frac{l_l}{r} = \frac{1}{r/\,l_l} \tag{3.5}$$

The factor $1/4$ is an unexplained correction factor for now and it also differs from Haramein's original definition where it had a different value and was part of equation 3.6 instead of equation 3.5. The correction factor issue will be revisited in section 3.8 which is why it will not be discussed in more detail here. Moreover, the astute reader may wonder about the packing scheme of the spherical PSUs and the space between them - this topic will also be addressed in depth in section 3.8.

Haramein discovered that he can calculate black holes masses as well as proton mass by using the information ratio ϕ_h together with the Planck mass and due to the concepts that led him to this insight he introduced the term 'holographic mass'. In case of the proton Haramein showed that it is possible to calculate its mass by simply multiplying the information ratio ϕ_h with the Planck mass:

$$m_\hbar = \phi_h\, m_l = \frac{l_l}{r_c} m_l = \frac{1}{r_c/\,l_l} m_l \tag{3.6}$$

The last equation will be referred to as the inverse holographic mass hereafter, which is denoted by the use of $\hbar$ in the subscript of mass m, because the particle radius appears as a fraction denominator in the last equation. Please note that the term $r_c/\,l_l$ denotes the quantized particle radius when assuming that the Planck length l_l constitutes the smallest possible length in our universe.
Using equations 3.1 and 3.2 the inverse holographic mass can alternatively be expressed as follows:

$$m_\hbar = \frac{1}{r_c}\sqrt{\frac{\hbar G}{c^3}}\sqrt{\frac{\hbar c}{G}} = \frac{1}{2\pi r_c}\frac{h}{c} = \frac{1}{\lambda_c}\frac{h}{c} = \frac{1}{r_c}\frac{\hbar}{c} \tag{3.7}$$

Astonishingly the last equation equals the Compton particle equation 2.12 which is the reason why the Compton radius r_c was already used in the previous two equations instead of a more generic radius r. This equality furthermore establishes the connectedness of the Compton particle model with Haramein's thinking, whereby this connection is also reflected by the presence of the Compton particle circumference $2\pi r_c$ in the last equation.

Please also note that the gravitational constant G is absent from equations 3.6 and 3.7, which is unexpected since mass and gravity should have a close relationship, but using equation 3.1 it is also possible to express the inverse holographic mass in terms of the gravitational constant G:

$$m_\hbar = \frac{l_l^2\, c^2}{r_c\, G} \tag{3.8}$$

The last equation is obviously more complicated than equation 3.7 and thus presumably also less fundamental. The unexpected absence of the gravitational constant G from fundamental equations will

also be encountered in other equations and discussed again in the upcoming sections.
Moreover, equation 3.8 is reminiscent of how black hole mass is usually stated since it features a c^2/G term. This is the second hint for a correlation between Compton particles and black holes, besides the speculation that a Compton particle surface is similar to a black hole horizon (see section 2.3), and the next section will investigate that correlation further.

The appropriate radii for the inverse holographic mass equations are the Compton particle radii as stated in table 1 of section 2.2. This section also mentioned that the proton radius deviation from the conventional radius is close to a factor of $1/4$ which encourages the following modification: removing the 'fudge factor' $1/4$ from equation 3.5 would make the inverse holographic mass compatible with the standard model of physics, i.e. the conventional proton radius could be used to calculate the proton mass using the inverted holographic mass. Doing so might be correct but there are symmetry and topology relationships in the upcoming sections which suggest that this would be inappropriate, in particular equation 3.54 and 3.55. Moreover, such a change would also create problems with the Compton particle model as presented in section 2 since equation 2.6, and anything derived from it, would have to be reconsidered.

3.3 BLACK HOLES

According to general relativity theory the mass of Schwarzschild metric black holes is given by

$$m_s = \frac{1}{2}\frac{r_s c^2}{G} \tag{3.9}$$

whereby r_s denotes the black hole's radius. As Haramein showed in (2) it is also possible to express equation 3.9 in terms of ϕ_h when rearranging it using equation 3.1 and 3.2:

$$m_s = \frac{1}{2}\frac{1}{\phi_h}m_l = \frac{1}{2}\frac{r_s}{l_l}m_l = \frac{1}{2}\frac{r_s}{\sqrt{\frac{\hbar G}{c^3}}}\sqrt{\frac{c\hbar}{G}} = \frac{1}{2}\frac{r_s c^2}{G} \tag{3.10}$$

This expression of the Schwarzschild mass is very similar to the inverted holographic mass as stated in equation 3.6 which is a remarkable link between the extremely small and the extremely large. These equations only differ by a factor of $1/2$ and ϕ_h is used in an inverse manner, whereby the latter constitutes an intriguing symmetry feature that results in a different mass scaling behaviour: Schwarzschild black holes, which are accumulations of Compton particles, possess mass that scales proportional to radius r whereas Compton particle mass scales proportional to $1/r$.

The revealed symmetry indicates that the holographic mass concept has merit but the Schwarzschild black hole is probably not be the appropriate symmetry partner for a Compton particle because this class of black holes does not possess rotation. The black hole type that also incorporates rotation is a Kerr metric black hole and the appropriate Compton particle symmetry partner is presumably a Kerr black hole that also rotates with light speed c at the edge of its equatorial plane, like a Compton particle does. Such a Kerr black hole has the following radius relationship to a Schwarzschild black hole of the same energy (10)

$$r_k = r_s/2 \tag{3.11}$$

and an angular frequency of:

$$\omega_k = \frac{c}{r_k} \tag{3.12}$$

This document will only consider Kerr black holes with an angular frequency of ω_k and refer to them as extreme Kerr black holes hereafter. Rotating black holes are likely not able to reach ω_k exactly (18) but that detail can be neglected for the purposes of this document.
Inserting equation 3.11 into equation 3.10 gives the mass equation for extreme Kerr black holes

$$m_k = \frac{r_k c^2}{G} \tag{3.13}$$

which can also be expressed in terms of ϕ_h and m_l:

$$m_h \equiv m_k = \frac{1}{\phi_h}m_l = \frac{r_k}{l_l}m_l \tag{3.14}$$

Equation 3.14 and 3.6 are evidently very similar, whereby the inverted use of the ϕ_h term is the only remaining difference, and thus extreme Kerr black holes can indeed be regarded as symmetry partner for Compton particles. Since considerations on black hole thermodynamics are the origin of the holographic principle, and since the presence of the information density ratio ϕ_h can be regarded as endorsement of the holographic principle, Haramein designated the term holographic mass to equation 3.10. This document, though, uses equation 3.14 as the definition of holographic mass m_h due to the better symmetry with equation 3.6. Using equation 3.1 it is also possible to express m_k without the gravitational constant G and the Planck mass m_l, which gives a holographic mass equation that features a $\hbar/c$ term again and is more similar to equation 3.7.

$$m_h \equiv m_k = \frac{\hbar}{c}\frac{r_k}{l_l^2} = \frac{\hbar}{\omega_k\, l_l^2} \tag{3.15}$$

The appearance of a l_l^2 term is noteworthy since it is central to the entropic gravity concept which is introduced in section 3.7 by using black hole thermodynamics.

The symmetry between extreme Kerr black holes and Compton particles can also be expressed through their energy equations and this similarity is again only apparent when utilizing the Planck units. Using equation 3.14 the energy of an extreme Kerr black hole can be expressed as follows

$$E_k = m_k c^2 = E_l \frac{r_k}{l_l} = E_l \frac{\omega_l}{\omega_k} \tag{3.16}$$

whereby E_l denotes the Planck energy $m_l c^2 = \hbar\omega_l$ and ω_l denotes the angular Planck frequency c/l_l. The energy of a Compton particle can be expressed in a similar way using equation 2.6:

$$E_c = m_\hbar c^2 = E_l \frac{l_l}{r_c} = E_l \frac{\omega_c}{\omega_l} \tag{3.17}$$

A question that remains, though, is if the Compton particle symmetry partner should also possess charge and if so, how much of it?

The function ϕ_h can also be used to form a direct relationship between extreme Kerr black hole mass m_k and inverse holographic mass $m_\hbar$

$$m_k \phi_h^2 = m_\hbar = m_h \phi_h^2 \tag{3.18}$$

but this relationship should not be of relevance since it is impossible for a black hole to possess the radius of any of the Compton particles, although there is one exception as pointed out in section 3.5. Trying to calculate the mass for a hypothetical black hole which has the size of a proton, with Compton radius r_{cp}, holds a numerical surprise, though:

$$\begin{aligned} m_s(r_s = r_{cp}) &\cong \sqrt{2} \times 10^{11}\ \text{kg} \\ m_k(r_k = r_{cp}) &\cong 2\sqrt{2} \times 10^{11}\ \text{kg} \end{aligned} \tag{3.19}$$

The deviation of these results is less than 0.13%, which is quite high for a result in particle physics, and therefore this numerical oddity might be dismissed, but more $\sqrt{2}$ oddities appear throughout this document which suggests that there is some underlying physical cause.

3.4 SCHRÖDINGER EQUATION - PART TWO

This section demonstrates that the time independent Schrödinger equation also yields interesting variants when adapting it for black holes. To accomplish this goal the $2m/\hbar^2$ term from equation 2.56 has to be rearranged using equation 2.49, 3.1, 3.9 and 3.11:

$$\frac{2m}{\hbar^2} = \frac{2m}{m_l^2\, l_l^2\, c^2} = \frac{r_s}{m_l^2\, l_l^2\, G} = \frac{r_s}{m_l^2\, l_l^2}\frac{m_l}{l_l c^2} = \frac{r_s}{V_l}\frac{1}{E_l} = 2\frac{r_k}{V_l}\frac{1}{E_l} \tag{3.20}$$

Here V_l denotes the cubic Planck volume l_l^3 and E_l denotes the Planck energy $m_l\, c^2$. Putting the last equation into equation 2.56 then gives the following variant of the time independent Schrödinger equation:

$$\frac{d^2\psi}{dx^2} + 2\frac{r_k}{V_l}\frac{E_{tot} - E_{pot}(x)}{E_l}\psi = 0 \tag{3.21}$$

Similar to equation 2.58 and 2.59 the energy term reduces to a dimensionless scaling term which is multiplied by a fraction that has the units $1/\text{m}^2$ - which is a sensible trait for the Schrödinger equation. The Planck volume V_l also makes sense here since the Schrödinger equation is concerned with three dimensional space, although equation 3.21 just treats the x component. Moreover, it is noteworthy that Planck units appear in the Schrödinger equation in a sensible way when adapting it for black holes which is further evidence for the connectedness of the very large and the very small and that this connection involves the Planck units.

3.5 PSU RELATIONSHIPS

This section will explore the relationships of Planck Spherical Units (PSUs) to other quantities and the first equation of this section already demonstrates a noteworthy relationship between a PSU's Planck mass m_l and holographic mass:

$$m_h(r_k = l_l) = m_\hbar(r_c = l_l) = m_l \tag{3.22}$$

PSUs are Compton particles as well as black holes, according to the last equation, and therefore the PSU, with its radius of one Planck length l_l, constitutes a kind of nexus point between the very small and the very large. This again demonstrates that the Planck length and Planck mass should be regarded as key properties of our universe and the conspicuously high value of the Planck mass (see equation 3.2) also starts to make sense. In public talks Haramein often stated that our universe should be built from micro black holes, for conceptual reasons, which is what the last equation essentially states when assuming that even space itself is built from PSUs. The uniqueness of the PSU's Planck mass can also be expressed by multiplying the inverse holographic mass with holographic mass which results in a geometric mean equation that is valid for arbitrary radii r:

$$m_l = \sqrt{m_h(r_k = r)\; m_\hbar(r_c = r)} \tag{3.23}$$

For better understanding a visual representation of these mass relationships is also provided in appendix B.

Knowing that PSUs are also Compton particles justifies using equation 2.3 to calculate a PSU's Compton frequency which is denoted by f_l hereafter:

$$f_l = \frac{c}{2\pi\, l_l} = 2.952\,147 \times 10^{42}\,\mathrm{Hz} \tag{3.24}$$

Multiplying f_l by 2π yields the angular frequency for PSUs which matches the angular Planck frequency ω_l:

$$\omega_l = 2\pi f_l = c/\, l_l = 1.854\,888 \times 10^{43}\,\mathrm{rad/s} \tag{3.25}$$

Please note that no object should be able to rotate faster than a PSU since the angular Planck frequency is expected to be the upper limit for angular frequency in our universe. Like for any other Compton particle the product of Planck's constant with its Compton frequency results in the particle's energy, i.e. $E_l = hf_l$, but since the PSU is too small to have self energy contributions as described in section 2.7 a PSU should rather be contemplated as pure energy which has condensed into a small spinning "drop". More precisely, at the PSU level energy and rotation must be regarded as synonymous because there is no material substance involved in a PSU's rotation which we could measure or split from within our universe and thus PSU rotation should be regarded as immaterial but energetic - a notion which has some similarity with the prevalent interpretation of a quantum physical wave-function since rotation and oscillation are closely related.

Nonetheless, an equivalent PSU mass $m_l = E_l/c^2$ can be defined which is of practical use. The gravitational constant G, for example, can also be expressed in terms of the Planck mass which allows expressing gravitational force with respect to the PSU mass:

$$G = \frac{c^2 l_l}{m_l} = \frac{c\hbar}{m_l^2} \tag{3.26}$$

$$F_g = a_g\, m = \frac{c^2 l_l}{d^2}\frac{mM}{m_l} \tag{3.27}$$

$$F_g = a_g\, m = \frac{c\hbar}{d^2}\frac{mM}{m_l^2} \tag{3.28}$$

Here the variables m and M denote two different and arbitrary masses. Please note that the $c\hbar/d^2$ term in equation 3.28 has the units of acceleration, i.e. $\mathrm{m/s^2}$, and the fraction involving masses is dimensionless. This fraction can also be expressed in different ways for the special case of two Compton particles as shown by the following equation

$$\frac{mM}{m_l^2} = \frac{1}{r_{cm}\, r_{cM}/\, l_l^2} = \frac{f_{cm} f_{cM}}{f_l^2} \tag{3.29}$$

whereby r_{cm}, r_{cM}, f_{cm} and f_{cM} denote the Compton radius and Compton frequency of mass m and M respectively. Please note that all fractions in the last equation are dimensionless as all variables get normalized with respect to their appropriate Planck unit.

For completeness's sake it is shown here that the gravitational force can also be expressed in terms of the so called Planck force $F_l = c\hbar/l_l^2$ whose physical meaning will be treated in more detail in section 4.1.

$$\frac{F_g}{F_l} = \frac{1}{d^2/\, l_l^2}\frac{mM}{m_l^2} \tag{3.30}$$

Expressing gravitational force in this form is interesting because each fraction in the last equation is dimensionless which produces an equation of normalized ratios with respect to the appropriate Planck unit. This form also allows an easy transformation of the last equation into a so called system of natural units where the Planck units are not treated as quantities in the SI unit system, like it is done throughout in this document, but as the base units of that unit system. A gravitational force equation could look like this in such a system

$$3\mathrm{f} = 3\mathrm{m}\, 4\mathrm{m}/(2\mathrm{l})^2$$

whereby f means Planck force, m means Planck mass, l denotes Planck length and division by the appropriate base unit is implicit. This scheme allows a compact expression of physical equations, and even the units might be omitted for brevity, but the property of dimensional consistency is lost and the Planck units are also not sensible base units for all quantities, e.g. it doesn't make sense to use light speed as reference for everyday velocities in human life. But it could make sense to define a shorthand notation for dividing by the appropriate Planck unit, or physical constant, and keep using the SI system of units to get equations of the following form:

$$F_g = c\hbar\,\check{m}\check{M}/d^2 = F_l\,\check{m}\check{M}/\check{d}^2$$
$$\check{v} = v/c = 1.498\,962 \times 10^8\,\mathrm{m\,s^{-1}}/\,c = 0.5$$

In any case, though, the physical meaning of the content presented in this document does not depend on the chosen system of units and the significance of the Planck units does not lie in their potential use as unit system, but in their role as a special and fundamental set of quantities for our universe.

3.6 GRAVITATIONAL POTENTIAL ENERGY

The gravitational potential energy equation $U_g = -GmM/d$ can be adapted to describe the self energy of Compton particles according to

$$E_c = Gm_l^2/r_c = mc^2 \tag{3.31}$$

which is analogous to how the electric potential energy equation 2.41 is structured. It's noteworthy that the Planck mass and Planck charge appear in connection with the Compton radius in equation 2.41 and 3.31 which again highlights the relevance of the Planck units. Please note that contemporary physics doesn't offer an explanation for why these two novel equations exist. The connection between Planck mass m_l and rest mass m, which is also present in equation 3.31, will be relevant for section 3.13 too, which examines the strong force.
For extreme Kerr black holes the corresponding potential energy equation is given by:

$$E_k = c^4/G\,r_k = Gm_l^2 r_k/\,l_l^2 = m_k c^2 \tag{3.32}$$

Based on equation 3.28 the gravitational potential energy can also be expressed as follows:

$$U_g = -\frac{c\hbar}{d}\frac{mM}{m_l^2} \tag{3.33}$$

Interestingly, it's possible to express the last equation as pure hf term when adapting it for Compton particles. To achieve this distance d must also be converted to a frequency which is easily done by defining the following relationship:

$$\omega_d = 2\pi f_d = c/d \tag{3.34}$$

Using the last equation and equation 3.29 the gravitational potential energy for two Compton particles can be expressed as follows:

$$U_{gcc} = -hf_d f_{cm} f_{cM}/f_l^2 \tag{3.35}$$

This relationship again highlights that hf terms do not apply exclusively to photons and it also raises the question if gravity could be related to Compton particle rotation. The validity of the last equation can be checked by taking its derivative with respect to distance d:

$$F_{gcc} = \frac{\mathrm{d}U_{gcc}}{\mathrm{d}d} = -h\frac{f_{cm}\,f_{cM}}{f_l^2}\frac{\mathrm{d}f_d}{\mathrm{d}d} = \frac{c\hbar}{d^2}\frac{f_{cm}\,f_{cM}}{f_l^2} \tag{3.36}$$

As expected an equation for gravitational force is obtained which is a variant of equation 3.28.

3.7 ENTROPIC GRAVITY - PART ONE

Verlinde theorized that gravity might be an emergent force whose true origin comes from entropy. He arrived at this notion by considerations that involved the holographic principle (5) and black hole thermodynamics. In (6) Verlinde demonstrated that it is indeed possible to obtain Newtonian gravity from entropic considerations and a compact recapitulation of his derivation is given in this section.

Verlinde first set a measure for information inspired by concepts which were proposed earlier in the context of black hole thermodynamics research. He assumed that the amount of information N on a sphere with radius r is given by how many Planck length sized squares can be put on the corresponding surface A, whereby each such square equals one bit of information.

$$N = \frac{A}{l_l^2} = \frac{4\pi r^2}{l_l^2} = \frac{4\pi r^2 c^3}{G\hbar} \tag{3.37}$$

Verlinde also reasoned that Schwarzschild black holes should be in thermal equilibrium and that their entropy is evenly distributed on their spherical surface. Then the equipartition theorem should apply which is given by

$$E = \frac{1}{2} N T_s k_b \tag{3.38}$$

whereby k_b denotes the Boltzmann constant with a value of $1.380\,649 \times 10^{-23}$ J/K and T_s denotes the temperature at the black hole horizon of a Schwarzschild black hole with mass M_s, mass energy

$$E_s = M_s c^2 \tag{3.39}$$

and a horizon temperature as given by the Hawking temperature:

$$T_s = \frac{c^3 \hbar}{8\pi G M_s k_b} \tag{3.40}$$

As Unruh showed in (9) an observer in vacuum with constant acceleration a will experience the following temperature:

$$T_u = \frac{1}{2\pi k_b} \frac{\hbar}{c} a \tag{3.41}$$

It's possible to replace acceleration a by F_g/m whereby m denotes the mass of a comparatively small particle that is located close to the black hole horizon and attracted with force F_g. Doing so gives:

$$T_u = \frac{1}{2\pi k_b} \frac{\hbar}{c} \frac{F_g}{m} \tag{3.42}$$

The radius of the Schwarzschild black hole horizon is given by $r_s = 2M_s G/c^2$ (equation 3.9) and using Newtonian gravitational acceleration a_g

$$a_g = GM/r^2 \tag{3.43}$$

the gravitational acceleration a_s due to a Schwarzschild black hole with mass M_s is given by:

$$a_s = GM_s/r_s^2 = c^4/(4M_s G) \tag{3.44}$$

Interestingly, this leads to the following equality at the Schwarzschild black hole horizon:

$$T_s = T_u(a = a_s) \tag{3.45}$$

Thus T_s can be replaced by the Unruh temperature T_u (equation 3.42) in equation 3.38. Moreover, inserting equation 3.37 into equation 3.38, using $E = E_s$ and subsequent rearranging for F_g then results in the equation for Newtonian gravity:

$$\begin{aligned} M_s c^2 &= \frac{1}{2} \frac{4\pi r^2 c^3}{G\hbar} k_b \frac{\hbar}{2\pi k_b c} \frac{F_g}{m} \\ F_g &= G\frac{m M_s}{r^2} \end{aligned} \tag{3.46}$$

This is a remarkable result which suggests that gravity might be based on entropy fundamentally and this result also highlights the importance of the Planck length due to its connection to fundamental information.

Moreover, Verlinde showed in public talks that the second law of thermodynamics can also be obtained from black hole thermodynamics. For a Schwarzschild black hole the rate of change of mass M_s with area A_s, as derived from general relativity theory, is given by

$$\frac{\mathrm{d}M_s}{\mathrm{d}A_s} = \frac{1}{2\pi} \frac{a_s}{4G} \tag{3.47}$$

whereby a_s denotes the gravitational acceleration at the horizon. Furthermore the entropy of a Schwarzschild black hole is given by the so called Bekenstein-Hawking entropy (11):

$$S_s = k_b \frac{A_s}{4l_l^2} = k_b \frac{4\pi r_s^2}{4l_l^2} = k_b \frac{\pi r_s^2}{l_l^2} \tag{3.48}$$

Replacing a_s in equation 3.47 by using equation 3.45 and using the derivative of equation 3.48 with respect to A_s gives:

$$\begin{aligned} \mathrm{d}M_s &= \frac{1}{2\pi} \frac{a_s}{4G} \mathrm{d}A_s \\ \mathrm{d}M_s &= \frac{1}{2\pi} \frac{2\pi k_b c T_s}{\hbar 4G} \frac{4l_l^2 \, \mathrm{d}S_s}{k_b} \\ \mathrm{d}M_s &= \frac{l_l^2 c}{\hbar G} T_s \, \mathrm{d}S_s \end{aligned} \tag{3.49}$$

Using equation 3.1 to substitute l_l^2 the last equation reduces to the second law of thermodynamics for a reversible process, which in this case describes the growth of a Schwarzschild black hole.

$$\mathrm{d}M_s c^2 = \mathrm{d}E_s = T_s\,\mathrm{d}S_s \tag{3.50}$$

Historically seen it were the uncovered relationships of black hole physics with thermodynamics which sparked the conjecture that gravity could be related to entropy.

Entropic gravity and holographic mass have the same conceptual origin, as mentioned before, and comparing equations 3.3, 3.37 as well as 3.48 reveals their connection:

$$N = \pi\eta = 4S_s/k_b \tag{3.51}$$

Here the factor π denotes the area conversion factor between circles with a radius of one Planck length and squares with a side length of one Planck length but since N and η are presumably quantities of information the factor π seems to be inappropriate here, which is why this relation is examined again in the next section.

3.8 PSU TOPOLOGY

The factor π in equation 3.51 suggests that the topology used for the holographic mass concept, as outlined in section 3.2, is not the 100% correct one. A proportionality constant between N and η should be an integer, or at least a rational number, since these quantities are assumed to be related to bits of information. Moreover, the equations for counting PSUs which were presented beforehand do not really explain how PSUs are packed in space. Assuming that the three dimensional view of space is still valid at the quantum level it is not possible to stack PSUs as described by equation 3.3 and 3.4 because then the corresponding sphere packing scheme would have to be without gaps and without overlap. One possible answer to this issue is that such considerations are nonsensical at the quantum level of space because PSUs are space and there is no in between. There may be other topologies, though, that also use the stated PSU properties as well as retain the holographic mass equations and the aim of this section is to introduce one such alternative topology.

A sensible first assumption is that a fundamental object's spherical surface should be filled with PSUs that overlap just enough to fill all of its surface without gaps. To achieve this the object's surface must be divided into small equal sized squares which are all circumscribed by the great circle of a PSU. These squares consequently have side length $l_l\sqrt{2}$, a diagonal length of $2l_l$ and an area of $2l_l^2$. Since such a square is vastly smaller than the surface of any fundamental object it is an appropriate approximation to simply divide areas to get the number of PSUs on the surface:

$$\eta_{sq} = \frac{4\pi r^2}{\left(l_l\sqrt{2}\right)^2} = \frac{4\pi r^2}{2l_l^2} = 2\pi\left(\frac{r}{l_l}\right)^2 \tag{3.52}$$

Figure 7 and 8 are representations of the last equation which visualize the corresponding surface structure.

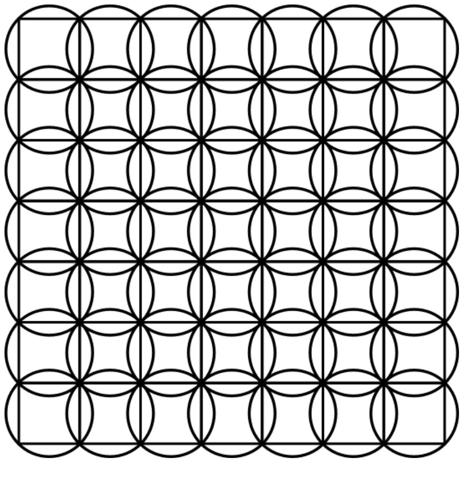

Figure 7: Surface pattern

Figure 8: Sphere of spheres

In numerous public talks Haramein suggested that the structure of space itself should be built from octahedrons in combination with tetrahedrons. Consequently, Compton particles and black holes should also be built from octahedrons and tetrahedrons, but at the time of writing Haramein did not release material

that shows how to incorporate this notion into his scientific work on protons and black holes.
Figure 9 & 10 depict these two fundamental geometries whose size is also chosen to be determined by the PSU, i.e. the octahedron is enclosed by a PSU and the tetrahedron edge length matches that of the octahedron. Consequently the octahedron must have an edge length of $l_l\sqrt{2}$ and a cross section along its edges has a square shaped area of $2l_l^2$. This area is identical to the square area used in equation 3.52 which signifies that each square in figure 7 represents an octahedron's cross section along its edges.
Only octahedrons and tetrahedrons with these properties are relevant in this document and for easier recognition the colouring scheme that is used for them in figure 9 & 10 will be used throughout this document, i.e. tetrahedrons are always depicted in blue and octahedrons are always depicted in red. Please note that these colours are not related to electric charge.

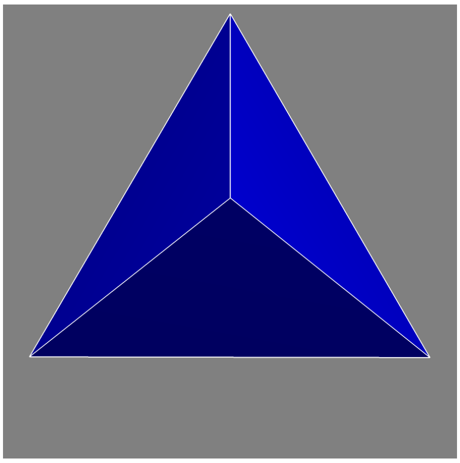

Figure 9: Tetrahedron

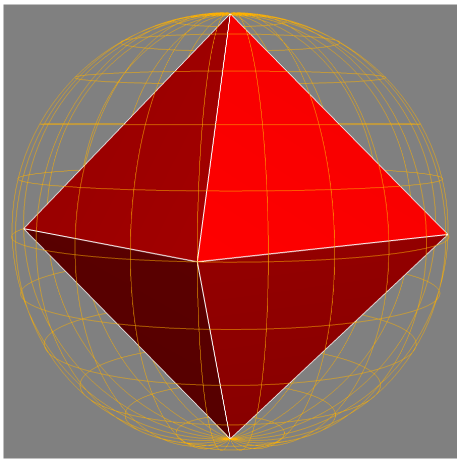

Figure 10: PSU enclosing octahedron

The octahedrons are furthermore assumed to form a structure which defines the correct placing of the PSUs in space, but octrahedrons alone are not space filling - as explained by Buckminster Fuller two tetrahedrons and one octahedron of the same edge length are required to fill space without gaps (12). Using this knowledge the number of PSUs inside a sphere, which is substantially larger than an individual PSU, can be approximated by the following calculation that simply divides a sphere's volume by the volume of one octahedron and two tetrahedrons with edge length $\sqrt{2}l_l$:

$$R_{oct} = \frac{4\pi r^3/3}{\frac{\sqrt{2}}{3}(\sqrt{2}l_l)^3 + 2\frac{\sqrt{2}}{12}(\sqrt{2}l_l)^3} = \frac{4\pi r^3/3}{\sqrt{2}\,l_l^3/2} = \frac{8\pi}{3\sqrt{2}}\left(\frac{r}{\sqrt{2}\,l_l}\right)^3 = \frac{2\pi}{3}\left(\frac{r}{l_l}\right)^3 \tag{3.53}$$

Figure 11 and 12 visualize the proposed space filling structure which also has further interesting properties. Its octahedrons and tetrahedrons can be arranged into larger octahedrons, for example, which constitutes a fractal relationship. Moreover, the proposed topology can also be regarded as only being constructed from equilateral triangles of identical size. Please note that triangles are also the commonly used geometry for computer generated virtual worlds and this similarity can be regarded as a kind of abstract reflection of how our universe is built at the fundamental level.

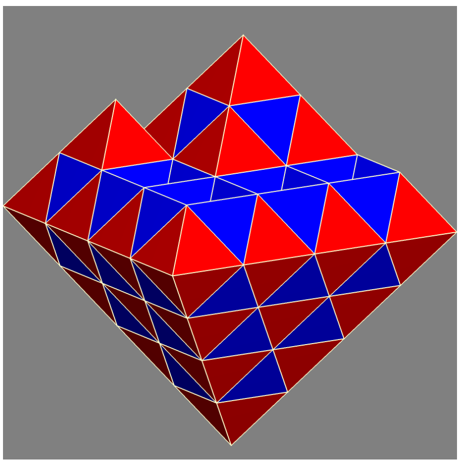

Figure 11: Stacked octahedrons

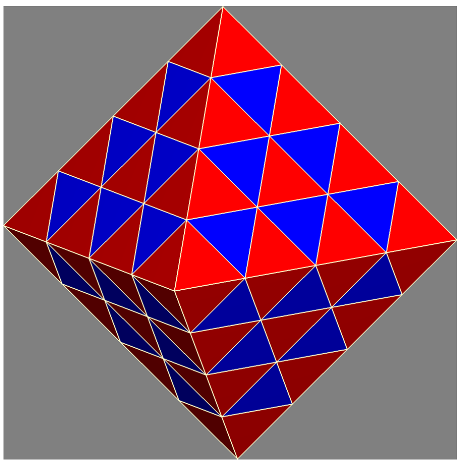

Figure 12: Fractal octahedron

Because of this triangular composition the surface of a fractal octahedron exhibits an intriguing property - it encodes the so called "flower of life" pattern which is depicted in figure 14 by yellow colour. Please note that each yellow circle in figure 14 has a radius of $l_l\sqrt{2}$ which is different from a PSU's radius of one Planck length.

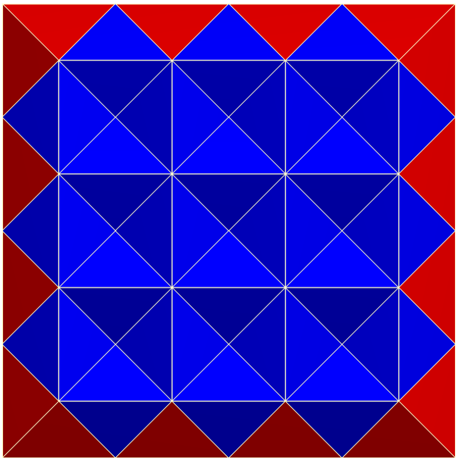

Figure 13: Pyramidal intake slots

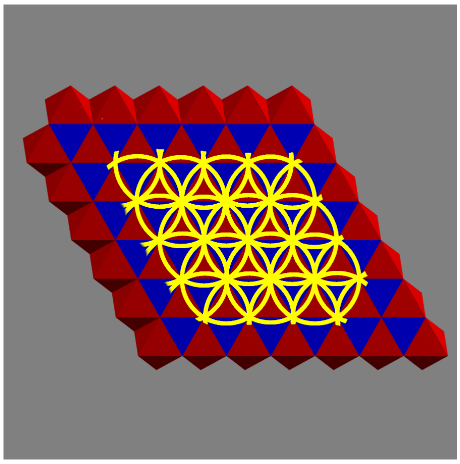

Figure 14: Flower of life pattern

Moreover, octahedrons and tetrahedrons can also be combined to form fractal tetrahedrons as shown in figure 15. The purpose of figure 16 is to elucidate the composition of the tetrahedron in figure 15.

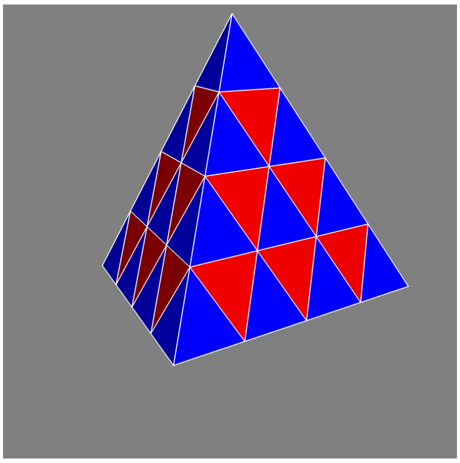

Figure 15: Fractal tetrahedron

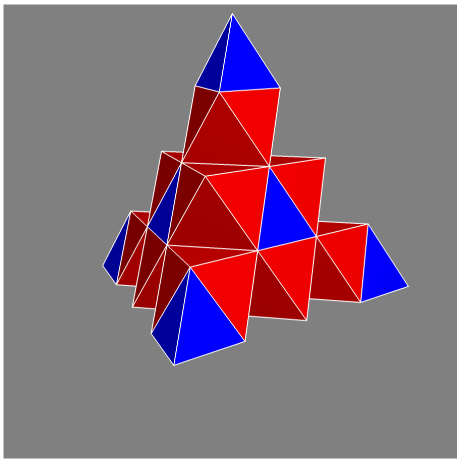

Figure 16: Fragmented tetrahedron

After having defined a new PSU topology it is now possible to express ϕ_h in an alternative way by using equation 3.52 and 3.53:

$$\phi_h = \frac{1}{3}\frac{\eta_{sq}}{R_{oct}} = \frac{l_l}{r} = \frac{1}{r/l_l} \tag{3.54}$$

The proportionality constant has changed from $1/4$ to $1/3$ compared to equation 3.5 but the number 3 is actually a sensible value in this context: for spheres it denotes the proportionality constant of volume V_{sph} to surface area A_{sph} according to $A_{sph} = 3V_{sph}/r$ and rearranging this area to volume relationship makes the connection to ϕ_h more obvious:

$$\frac{1}{r} = \frac{1}{3}\frac{A_{sph}}{V_{sph}} = \frac{\phi_h}{l_l} \tag{3.55}$$

Consequently, equation 3.54 should be regarded as the quantized version of equation 3.55 and thus ϕ_h represents a method to calculate the inverse of the quantized radius r/l_l from quantized volume R_{oct} and quantized area η_{sq}. If equation 3.55 should also be regarded as information density ratio, like equation 3.5, is questionable considering its geometric meaning.

Haramein publicly promoted an octahedron and tetrahedron based topology for space that he called the "64 tetrahedron grid". This structure contains the fractal properties which were outlined above as well as the "flower of life" pattern and was inspired by the thinking of Richard Buckminster Fuller. In his book "Synergetics" Fuller noted that cuboctahedrons are the only platonic solid in "vector equilibrium" (12), which means that all internal vectors of a cuboctahedron cancel out. Therefore Haramein concluded that the cuboctahedron should be a part of the fundamental space-time geometry and the cuboctahedron is actually also covertly contained in the presented topology. This can be demonstrated by cutting the magenta coloured octahedrons of figure 17 in half which will produce the cuboctahedron of figure 18. The resulting cuboctahedron consists of six magenta coloured pyramids facing inwards and eight tetrahedrons in blue colour which are situated between the pyramids.

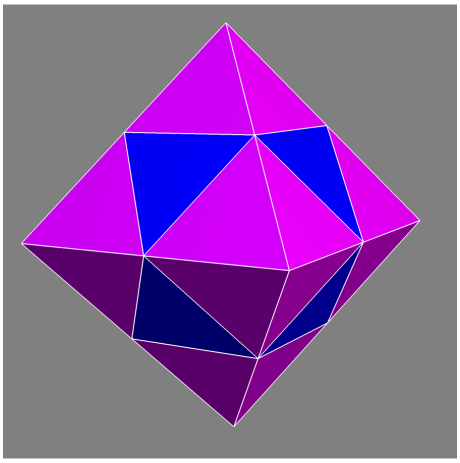

Figure 17: Group of six octahedrons

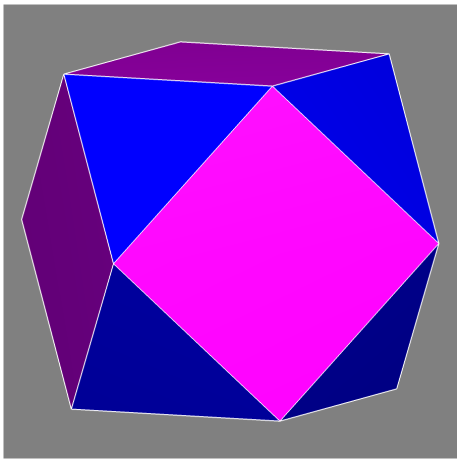

Figure 18: Cuboctahedron

Thus each group of six neighbouring octahedrons is embedded into a cuboctahedron structure which presumably provides the maximum possible stability and balance to space. Depending on the scale at which the PSU topology is examined its geometry features fractal octagons, fractal tetrahedrons and fractal cuboctahedrons of varying sizes which are all intertwined. Since the presented PSU topology also contains sheets of hexagonal geometry, which are embedded into the three possible cross sections of the cuboctahedron along its edges, the presented PSU topology can also be regarded as a hexagonal crystal or, figuratively speaking, as a stack of skewed honey combs.

The presented topology presumably provides the configuration space in which everything exists and fundamental particles should be regarded as dynamic patterns in this structure. When a PSU or particle moves inside this structure it does not "flow" in the common sense of an object moving through empty space, but instead it is presumed here that a sequence of distinct configuration changes takes place which appears like an object's continuous motion. According to this notion nothing really moves physically in this structure, only state changes are happening at fixed time intervals. This process should be comparable to what happens in computers where individual binary memory cells can change their information content in cyclic updates but still the grid of physical memory cells is static. Hence this conception of space is not a revival of the ether concept and more like a computer generated virtual reality which also constitutes a link to the entropic gravity notion as both subjects are closely related to information.

The PSU topology as presented in this section has the following relationship to N (equation 3.37)

$$N = 2\,\eta_{sq} \tag{3.56}$$

which makes more sense than equation 3.51 since the factor π has been replaced by an integral number. But what is the role of the factor two? Assuming that a Planckian bit is defined by an area of l_l^2 the last equation states that each PSU contains two bits of information. PSUs are presumed to be equal in most of their internal properties and these two bits may represent their differences. Possible candidates for these differences are spin $\uparrow\downarrow$ and positive / negative charge.

3.9 SECOND LAW OF THERMODYNAMICS

It was shown in section 3.7 that equation 3.47 leads to the second law of thermodynamics when using the Bekenstein-Hawking entropy S_s (equation 3.48) and the Unruh temperature T_u (equation 3.41), but equation 3.47 can be generalized and simplified using equation 3.43 to get the following relationship for the change of mass M with respect to area A:

$$\frac{\mathrm{d}M}{\mathrm{d}A} = \pm\frac{1}{2}\frac{M}{A} \tag{3.57}$$

This relationship does not only apply to Schwarzschild black holes, as delineated in section 3.7, but to extreme Kerr black holes and Compton particles as well. Please note that the $\pm$ symbol in equation 3.57 denotes a minus for the Compton particle case and a plus in all other cases as this scheme will be used throughout this section.
The differential relationship as described by equation 3.57 can also be obtained by applying derivation: M is $\propto \sqrt{A}$ for Schwarzschild black holes and extreme Kerr black holes. Then the derivative of M with respect to A is $\propto 1/(2\sqrt{A})$ but $M/(2A)$ is also $\propto 1/(2\sqrt{A})$. In the Compton particle case the situation is similar: M is $\propto 1/\sqrt{A}$ and the derivative with respect to A is $\propto -1/(2A\sqrt{A})$ as is $-M/(2A)$.

Section 3.7 demonstrated that the Unruh temperature and the Hawking temperature are identical at a Schwarzschild black hole's radius when the associated acceleration is caused solely by the Newtonian gravity of the black hole's mass M.

$$T_s = T_u\left(a = \frac{GM_s}{r_s^2}\right) = \frac{1}{2\pi k_b}\frac{\hbar}{c}\frac{GM_s}{r_s^2} \tag{3.58}$$

This correlation can be generalized further by introducing a gravitational temperature T_g which is defined in terms of mass M and the corresponding surface area A. Expressing the gravitational temperature can be done in a variety of ways using equation 3.1, 3.37, 3.48, 3.52 and $E_M = Mc^2$:

$$T_g = \frac{2G}{k_b}\frac{\hbar}{c}\frac{M}{A} = \frac{2Mc^2}{k_b}\frac{l_l^2}{A} = \frac{2E_M}{k_b}\frac{l_l^2}{A} = \frac{E_M}{k_b}\frac{l_l^2}{2\pi r^2} = \frac{2E_M}{k_b N} = \frac{E_M}{k_b \eta_{sq}} = \frac{1}{2}\frac{E_M}{S_s} \tag{3.59}$$

The presence of N, η_{sq} and S_s reveals the connection to black hole mass and holographic mass as described in previous sections. Therefore, and because the gravitational temperature uses the ratio M/A which is characteristic for each type of fundamental object, T_g is expected to describe the surface temperature of Schwarzschild black holes, extreme Kerr black holes as well as Compton particles when they are in thermal equilibrium. Please note that the gravitational temperature will be used in two different ways hereafter, and to avoid confusion the symbols T_{gv} and T_{gf} will be used to distinguish these use cases. In the T_{gv} case all variables, i.e. M, E_M, A, N, η_{sq} and S_s, are varying with radius r as a surface temperature is calculated, but in the T_{gf} case all variables are fixed except r which must be interpreted as distance in that case.

Examining the last equation further reveals that the gravitational temperature contains the equipartition theorem for one degree of freedom since individual bits, which are denoted by the variable N, can be considered as having one degree of freedom. A rearranged version of the last equation states the equipartition theorem in a more familiar way:

$$\frac{1}{2}Nk_bT_{gv} = \frac{1}{2}\frac{A}{l_l^2}k_bT_{gv} = \eta_{sq}k_bT_{gv} = E_M \tag{3.38}$$

In the entropic view of gravity the Hawking temperature T_s should be regarded as a special case of the gravitational temperature, i.e. $T_s \equiv T_{gv}(r = r_s, M = m_s)$, whereas the gravitational temperature should be regarded as a consequence of the equipartition theorem and entropy. The surface temperature of an extreme Kerr black hole should also be regarded as a special case, i.e. $T_k \equiv T_{gv}(r = r_k, M = m_k) = 4T_s$.

Using equation 3.57 together with the gravitational temperature shows that the growth of Compton particles, Schwarzschild black holes as well as extreme Kerr black is governed by the second law of thermodynamics, which is a generalization of what was already demonstrated in section 3.7. Substituting M/A in equation 3.57 by using the gravitational temperature gives

$$\frac{\mathrm{d}M}{\mathrm{d}A} = \pm\frac{k_b}{4G}\frac{c}{\hbar}T_{gv} = \pm\frac{1}{4}\frac{k_b}{l_l^2c^2}T_{gv} \tag{3.60}$$

which again leads to the second law of thermodynamics

$$\begin{aligned}\frac{\mathrm{d}Mc^2}{\mathrm{d}A} &= \frac{\mathrm{d}E_M}{\mathrm{d}A} = \pm\frac{1}{4}\frac{k_b}{l_l^2}T_{gv}\\ \frac{\mathrm{d}Mc^2}{\mathrm{d}S} &= \frac{\mathrm{d}E_M}{\mathrm{d}S} = \pm T_{gv}\end{aligned} \tag{3.61}$$

when

$$\mathrm{d}S = \frac{1}{4}\frac{k_b}{l_l^2}\,\mathrm{d}A \tag{3.62}$$

The last equation can be derived from the Bekenstein-Hawking entropy for Schwarzschild black holes as stated in equation 3.48. Since equations 3.61 & 3.62 were attained by using equations that are applicable to extreme Kerr black holes, Schwarzschild black holes as well as Compton particles it makes sense to assume that the Bekenstein-Hawking entropy is also valid for all these cases and thus it will be referred to as the holographic entropy S_h from now on to reflect the more general meaning.

$$S_h \equiv S_s = k_b\frac{A}{4l_l^2} = k_b\frac{N}{4} = k_b\frac{\eta_{sq}}{2} \tag{3.63}$$

Please note that the holographic entropy is not applicable to PSUs because A/l_l^2 is only a sensible quantity when a surface area A is much larger than l_l^2. This issue can be resolved by defining η_{sq} to be 1 for a PSU which then results in a PSU entropy that is given by $S_l = k_b/2$.

The surface temperature of a Compton particle can be defined in terms of its Compton radius, using the gravitational temperature together with equation 3.6, and this special case is referred to as the Compton temperature T_c hereafter.

$$T_c \equiv T_g(r = r_c, M = m_\hbar) = \frac{Mc^2}{k_b}\frac{1}{\eta_{sq}} = \frac{c\hbar}{2\pi k_b}\frac{l_l^2}{r_c^3} = \frac{E_l}{2\pi k_b}\frac{1}{r_c^3/l_l^3} \tag{3.64}$$

Calculating some Compton temperatures gives surprisingly low results: the proton has 1.02×10^{-26} Kelvin surface temperature and the electron 1.65×10^{-36} Kelvin. These temperatures are still far below the cosmic microwave background temperature of 2.73 Kelvin which might explain why experiments never revealed a connection between gravity and thermodynamics. On the other hand, black holes also have extremely low temperatures, e.g. a Schwarzschild black hole with the mass of our sun would only have 6.1×10^{-8} Kelvin surface temperature, which makes it plausible that Compton particles also have extremely low temperatures.

Using the pressure relationship $P = \delta E/\delta V$, which relates change in volume to change in energy, it is also possible to define the pressure at a Compton particle's surface. This pressure is denoted as Compton pressure and its magnitude is given by

$$P_c = \frac{1}{2}\frac{k_b T_c}{r_c\, l_l^2} = \frac{4\pi P_l}{N^2} = \frac{1}{4\pi}\frac{P_l}{r_c^4/l_l^4} = \frac{c\hbar}{4\pi}\frac{1}{r_c^4} \tag{3.65}$$

whereby P_l denotes the Planck pressure $P_l = F_l/\,l_l^2 = c\hbar/\,l_l^4$. Using $P = F/A$ a corresponding centripetal force can be defined which is denoted as Compton force:

$$F_c = P_c\, A = \frac{P_l\, l_l^2}{r_c^2/l_l^2} = \frac{4\pi F_l}{N} = \frac{F_l}{r_c^2/l_l^2} = \frac{c\hbar}{r_c^2} = m a_c \tag{3.66}$$

As can be seen in the last equation the Compton force F_c is linked to the Compton acceleration a_c (equation 2.51) and it is presumed here that the gravitational force F_g must match F_c at a Compton particle's surface for a seamless force transition - an assumption which will be examined further in section 3.13.

Defining the surface temperature of a PSU requires some care because η_{sq}, N and A/l_l^2 are no valid quantities for a PSU since it is too small. This issue can also be resolved by defining η_{sq} to be 1 for a PSU and using the equipartition theorem (equation 3.38). The PSU temperature is then simply given by

$$T_l = \frac{E_l}{\eta_{sq} k_b} = \frac{m_l c^2}{k_b} = 1.416\,807 \times 10^{32}\ \mathrm{K} \cong \sqrt{2} \times 10^{32}\ \mathrm{K} \tag{3.67}$$

which equals the Planck temperature T_l. This result is equal to calculating the gravitational temperature with an area A of $(\sqrt{2}l_l)^2$ instead of $4\pi l_l^2$

$$T_l = \frac{2G}{k_b}\frac{\hbar}{c}\frac{m_l}{(\sqrt{2}l_l)^2} = \frac{2m_l c^2}{k_b}\frac{l_l^2}{(\sqrt{2}l_l)^2} = \frac{m_l c^2}{k_b} = 1.416\,807 \times 10^{32}\ \mathrm{K} \tag{3.68}$$

whereby $2l_l^2$ matches the square area associated with a PSU (see equation 3.52 and figure 7). Using the Planck temperature also gives the following relationships which highlight the relevance of the Planck units:

$$T_s = \frac{T_l}{8\pi}\frac{m_l}{m_s}\ ,\ T_k = \frac{T_l}{2\pi}\frac{m_l}{m_k} \tag{3.69}$$

$$T_c = \frac{T_l}{2\pi}\frac{m_\hbar^3}{m_l^3} \tag{3.70}$$

Please also note that equation 3.67 and the following two equations contain further $\sqrt{2}$ oddities with a deviation of less than 0.2%, 0.1% and 0.9% respectively.

$$k_b\, T_c(r_c = r_{cp}) = m_p c^2/\eta_{sq}(r = r_{cp}) = 1.413\,024 \times 10^{-49}\ \mathrm{J} \cong \sqrt{2} \times 10^{-49}\ \mathrm{J} \tag{3.71}$$

$$k_b\, T_c(r_c = r_{ce}) = m_e c^2/\eta_{sq}(r = r_{ce}) = 2^4 \times 1.426\,786 \times 10^{-60}\ \mathrm{J} \cong 16\sqrt{2} \times 10^{-60}\ \mathrm{J} \tag{3.72}$$

These last two equations are specialized variants of the equipartition theorem (equation 3.38) and denote the average Compton particle energy per surface PSU for the proton and electron respectively.

3.10 ENTROPIC GRAVITY - PART TWO

The derivation of Newtonian gravity from thermodynamic considerations, as shown in section 3.7, only considered the special case of gravity at a Schwarzschild black hole horizon, but the generalizations presented in the previous section allow a more generalized derivation of Newtonian gravity. The only additional assumption necessary is that the equipartition theorem (equation 3.38), and consequently also the gravitational temperature, are valid at distances greater than the radius of a gravitational source. Thus the variable r in equation 3.59 should be reinterpreted as distance d and since the self energy of the gravitational source is assumed to be constant the previously introduced symbol T_{gf} will be used here. Subsequently, the gravitational temperature T_{gf_M} associated with a mass M has to fall $\propto 1/d^2$ as area A grows $\propto d^2$, which leads to the range characteristic of Newtonian gravity. Rearranging equation 3.59 to get an expression for gravitational acceleration a_g caused by the presence of mass M with energy $E_M = Mc^2$ makes these relationships more obvious:

$$a_g = \frac{GM}{d^2} = \frac{c^3 l_l^2}{\hbar}\frac{M}{d^2} = \frac{c}{\hbar}\frac{E_M}{d^2/\,l_l^2} = 4\pi\frac{c}{\hbar}\frac{E_M}{A/l_l^2} = 2\pi\frac{c}{\hbar}\frac{E_M}{\eta_{sq}(r=d)} = 2\pi\frac{c}{\hbar}k_b\,T_{gf_M}(r=d) \tag{3.73}$$

The last equation suggests that the presence of a gravitational source somehow affects the entropy & temperature of the surrounding space, as T_{gf_M} changes with distance, and that this circumstance should be causal for gravitational acceleration.
Comparing equation 3.73 with equation 2.51 reveals that, for the special case of mass M being a Compton particle, the relationship of gravitational acceleration and Compton acceleration is given by

$$a_g = \frac{a_c(E_c = E_M)}{d^2/\,l_l^2} \tag{3.74}$$

which indicates that the gravitational acceleration is an extension of the Compton acceleration. This relation also suggests that gravity has a relationship with Compton particle spin and section 3.12 will examine this idea in more detail. Moreover, section 3.13 looks into the matter of acceleration in close proximity to a Compton particle's surface because $a_g \neq a_c$ at $r_c = d$ and this doesn't match with the notion that gravitational acceleration is an extension of the Compton acceleration.

Equation 3.73 provided new expressions for gravitational acceleration which subsequently leads to new gravitational force equations. For brevity it is sensible to first define the following quantity

$$g_t = 2\pi k_b\frac{c}{\hbar} = 2.466\,083\times10^{20}\,\frac{\mathrm{m/s^2}}{\mathrm{K}} \tag{3.75}$$

which also allows a more compact expression of equation 3.73:

$$a_g = g_t \times T_{gf_M}(r=d) \tag{3.76}$$

The gravitational force between a mass $M = E_M/c^2$ and $m = E_m/c^2$, which are separated by distance d, can then be expressed as follows from the perspective of energy and temperature:

$$F_g = \frac{G}{c^4}\frac{E_M E_m}{d^2} = \frac{1}{c\hbar}\frac{E_M E_m}{d^2/\,l_l^2} = m \times g_t \times T_{gf_M}(r=d) \tag{3.77}$$

The last equation can be simplified further for the special case of mass m being a Compton particle as each type of Compton particle has a characteristic gravity related factor:

$$g_c = \frac{2\pi k_b}{r_c} = \frac{4\pi^2 k_b}{\lambda_c} \tag{3.78}$$

This factor evaluates to $4.124\,825\times10^{-7}\,\mathrm{N/K}$ for the proton and to $2.246\,450\times10^{-10}\,\mathrm{N/K}$ for the electron. Newtonian gravity for Compton particles can then be stated in the following form

$$F_{gc} = g_{cm} \times T_{gf_M}(r=d) \tag{3.79}$$

using the g_c factor whereby g_{cm} denotes the factor corresponding with mass m.

The equations presented in this section are expected to be valid for all cases where Newtonian gravity is an appropriate approximation. Other cases will require a better understanding of the relationship between entropic gravity and general relativity theory - a topic which is considered in the discussion section.

3.11 BLACKBODY RADIATION

Assuming that a black hole is an approximate black-body radiator its emitted power P, associated with a surface temperature T and surface area A, can be calculated according to

$$P = \sigma T^4 A \tag{3.80}$$

whereby $\sigma = 5.670\,367 \times 10^{-8}\,\mathrm{W\,m^{-2}\,K^{-4}}$ denotes the Stefan-Boltzmann constant. Combining the last equation with the gravitational temperature (equation 3.59) gives a quantity which will be referred to as gravitational power P_g hereafter.

$$P_g = \sigma T_g^4 A = \sigma \left(\frac{2G}{k_b} \frac{\hbar}{c} \frac{M}{A} \right)^4 A = \sigma \left(\frac{2G}{k_b} \frac{\hbar}{c} \right)^4 \frac{M^4}{A^3} \tag{3.81}$$

The gravitational power can be used to calculate the power emission of a Schwarzschild black hole and for this calculation it is helpful to express its surface area in terms of mass. Using equation 3.9 the sought-after surface area can be expressed in terms of Schwarzschild mass m_s as follows:

$$A_s = 4\pi r_s^2 = \frac{16\pi G^2 m_s^2}{c^4} \tag{3.82}$$

Using A_s to substitute A in equation 3.81 then gives the power emitted by a Schwarzschild black hole in terms of its mass:

$$P_{gs} = \sigma \left(\frac{2G}{k_b} \frac{\hbar}{c} \right)^4 \frac{m_s^4 c^{12}}{4^6 \pi^3 G^6 m_s^6} = \frac{\sigma c^8 \hbar^4}{4^4 \pi^3 G^2 m_s^2 k_b^4} = \frac{\sigma T_l^4 l_l^2}{4^4 \pi^3} \frac{m_l^2}{m_s^2} \tag{3.83}$$

The last equation shows that the radiated power is proportional to $1/m_s^2$. Thus if two Schwarzschild black holes of mass M merge to form another Schwarzschild black hole with mass $2M$ the emitted power of the resultant black hole is 1/4th compared to one of the former black holes and only 1/8th compared to the combined emission of the former two black holes. This effectively makes gravity a cooling process and substantiates the notion of a thermodynamic gravity. Repeating the power emission calculation for extreme Kerr black holes by using equation 3.13 and area $A_k = 4\pi r_k^2$ gives a similar equation

$$P_{gk} = \sigma \left(\frac{2G}{k_b} \frac{\hbar}{c} \right)^4 \frac{m_k^4 c^{12}}{4^3 \pi^3 G^6 m_k^6} = \frac{\sigma c^8 \hbar^4}{4\pi^3 G^2 m_k^2 k_b^4} = \frac{\sigma T_l^4 l_l^2}{4\pi^3} \frac{m_l^2}{m_k^2} = 4^3 P_{gs} \tag{3.84}$$

which shows that extreme Kerr black holes emit substantially more power than Schwarzschild black holes with identical mass.
Assuming that a power emission calculation might also make sense for a Compton particle gives the following result (*note: using T_g instead of T_c gives the same result*):

$$P_{gc} = \sigma\, T_c^4 A = \sigma \left(\frac{c\hbar}{2\pi k_b} \frac{l_l^2}{r_c^3} \right)^4 4\pi r_c^2 = \frac{\sigma c^4 \hbar^4 l_l^8}{4\pi^3 k_b^4 r_c^{10}} = \frac{\sigma T_l^4 l_l^2}{4\pi^3} \frac{m^{10}}{m_l^{10}} \tag{3.85}$$

According to the last equation a proton radiates 3.458×10^{-142} W and an electron radiates 7.941×10^{-175} W. This result fits with the observation that protons and electrons are very stable particles which do not disintegrate over time spans that can be measured experimentally.
PSUs are also expected to be non-radiative since they presumably are the smallest building block of our universe.

3.12 GRAVITATIONAL CONSTANT

The absence of the gravitational constant G in many expressions for mass (3.7 & 3.15), self energy (2.48), gravitational force (3.27, 3.28, 3.73, 3.77, 3.79, 3.98) and gravitational potential energy (3.35) suggests that G should be regarded as an emergent constant. This makes sense when assuming that the Planck length is a fundamental property of our universe because then all terms in the definition of $G = c^3\, l_l^2/\hbar$ (equation 3.88) are already fundamental constants. But still the question remains what G really means and regarding it as emergent constant also brings conflict with general relativity theory which utilizes G as a fundamental constant in the so called Einstein tensor.

Haramein noted that all planets, suns, fundamental particles and spiral galaxies have spin which led him to the idea that gravity might be the fundamental cause of their spin. This thinking is contrary to general relativity theory where rotating mass is seen as cause for the so called space-time dragging. If Haramein's interesting conjecture is correct gravity should always be associated with some kind of vortex and Schwarzschild black holes should transform into extreme Kerr metric black holes over time even without gaining angular momentum from in-falling mass.

The proposition made here is that the gravitational constant G is linked to Compton particle rotation. Since a two dimensional approach was already useful for spin (section 2.3) and magnetic moment (section 2.4) a similar approach is used here for gravity by examining the case of a two dimensional vortex that is caused by a mass M and which attracts a second mass m. This two dimensional vortex can be approximated as a series of rotating rings with constant velocity when the change of velocity between individual rings is negligible. The circular motion of these rings, which have a tangential velocity v_t that varies with distance d, is assumed to cause a centripetal acceleration v_t^2/d which is equal to the gravitational acceleration. Using this model the gravitational force F_g caused by such a two dimensional vortex can be expressed as:

$$F_g = m a_g = m\frac{v_t^2}{d} = G\frac{mM}{d^2} \tag{3.86}$$

Since this simple model only considers centripetal acceleration it will not be able to model frame dragging effects which require a tangential acceleration component. But nonetheless, this simple model already produces some interesting results as shown hereafter.

The objective of this section is to find vortex velocity profiles for which v_t^2/d mimics the Newtonian gravitational acceleration GM/d^2. To achieve this goal equation 3.86 has to be rearranged to express the gravitational constant in terms of v_t:

$$G = v_t^2\frac{d}{M} \tag{3.87}$$

Using the definition of the Planck length as given by equation 3.1 the gravitational constant can also be expressed as follows:

$$G = \frac{l_l^2 c^3}{\hbar} \tag{3.88}$$

Equating the last two expressions for G gives the following equation for the tangential velocity

$$v_t = \sqrt{\frac{l_l^2 c^3}{\hbar}\frac{M}{d}} \tag{3.89}$$

which is examined in more detail for Compton particles and black holes hereafter.

Using the inverse holographic mass equation 3.6 to substitute mass M by the corresponding radius r_{cM} the tangential vortex velocity for the Compton particle case is given by:

$$v_{tc} = \sqrt{\frac{l_l^2\, c^3}{\hbar}\frac{\hbar}{c\, r_{cM}}\frac{1}{d}} = c\frac{l_l}{\sqrt{d\, r_{cM}}} = c\frac{1}{\sqrt{d\, r_{cM}/\, l_l^2}} \tag{3.90}$$

The last equation can also be expressed in the following way

$$\frac{v_{tc}^2}{c^2} = \frac{l_l^2}{d\, r_{cM}} \tag{3.91}$$

which makes it more obvious that this result is actually sensible: the maximum vortex speed is predicted to be c because the term $d \times r_{cM}$ cannot become less than l_l^2 when assuming that the Planck length is the smallest possible distance in our universe. The predicted velocities are also very low: one nano meter away from a single proton the calculated vortex velocity is only around 10^{-14} m/s. The case of d being very close to r_{cM} will be examined in the next section.
Replacing v_t in equation 3.87 by v_{tc} gives a new expression for the gravitational constant which reveals why G can have a constant value despite its hypothesized vortex association:

$$G = \frac{l_l^2 c^2}{d\, r_{cM}}\frac{d}{M} = \frac{l_l^2 c^2}{r_{cM} M} = \frac{l_l^2 c^4}{r_{cM} E_M} \tag{3.92}$$

This expression of G is constant because the term $r_{cM} \times M$ equals the constant term $\hbar/c$ for Compton particles, which can be recognized by looking at equation 3.7 or 2.49, and consequently equation 3.92 & 3.88 are equal. Using the centripetal acceleration equation for circular motion again the relationship of gravitational acceleration to tangential velocity v_{tc} can be stated as follows for Compton particles:

$$a_{gc} = \frac{v_{tc}^2}{d} = \frac{c^2}{r_{cM}}\frac{1}{d^2/\, l_l^2} = \frac{a_{cM}}{d^2/\, l_l^2} \tag{3.93}$$

The gravitational acceleration term $c^2/r_{cM}\,(d/l_l)^{-2}$ is noteworthy since it only contains units of length and time as $c = l_l/t_l$, whereby t_l denotes the Planck time - whose role is explained in section 3.16.

The same calculation can be repeated for extreme Kerr black holes by using equation 3.15 to substitute mass M with the corresponding radius r_{kM} in the tangential velocity equation 3.89. Doing so gives the following vortex velocity profile for extreme Kerr black holes:

$$v_{tk} = c\sqrt{\frac{r_{kM}}{d}} = c\frac{1}{\sqrt{d\,/r_{kM}}} \tag{3.94}$$

The predicted maximum vortex velocity is again light speed c which will be reached at the black hole horizon. This result shows that the extreme Kerr black hole mass m_k (equation 3.13, 3.14, 3.15) implicitly contains

the information that an extreme Kerr black hole rotates with light speed at its equatorial plane. The same can be said about the Planck mass m_l as shown in section 3.13.
Replacing v_t in equation 3.87 by v_{tk} gives an equation for G which is a variant of the extreme Kerr black hole mass as stated in equation 3.13:

$$G = c^2 \frac{r_{kM}}{M} = c^4 \frac{r_{kM}}{E_M} \tag{3.95}$$

The last equation also yields a constant value for G regardless of the black hole's size. Getting two sensible velocity profiles for the gravitational constant (equation 3.87) is remarkable, as it would also have been possible to get nonsensical velocity results, and thus the presented velocity profiles indicate that G has an intrinsic association with rotation in general.
Using the centripetal acceleration equation for circular motion again the relationship of gravitational acceleration to tangential velocity v_{tk} can be stated as follows for extreme Kerr black holes

$$a_{gk} = \frac{v_{tk}^2}{d} = \frac{c^2}{d} \frac{1}{d/r_{kM}} \tag{3.96}$$

whereby the predicted maximum acceleration at $d = r_{kM}$ is given by c^2/r_{kM}.

The distinction between the gravitational acceleration of Compton particles and black holes can be reconciled by substituting the radius in a_{gc} and a_{gk} with the appropriate mass equation. In both cases this substitution leads to the same gravitational acceleration in terms of mass or energy:

$$a_g = \frac{c}{\hbar} \frac{Mc^2}{d^2/l_l^2} = \frac{c}{\hbar} \frac{E_M}{d^2/\, l_l^2} \tag{3.97}$$

The last equation is equal to the gravitational acceleration as stated in equation 3.73 which demonstrates that the gravitational vortex conjecture fits with the thermodynamic gravity approach.

Please note that temperature and energy must always be linked to some kind of motion, or potential for motion, and the two dimensional gravitational vortex seems to fulfil that requirement for thermodynamic gravity, but the presented vortex model is probably too simplistic and its physical meaning in three dimensional space is also not clear yet. Does the vortex imply some kind of PSU flow pattern in three dimensional space or is the vortex related to the curvature, pressure, temperature and/or entropy of space? Moreover, the two dimensional vortex conjecture might also be related to the presumed two dimensional holographic surface of our universe.

3.13 STRONG FORCE

Haramein suggested that the strong force might actually be gravitational in nature and he has also done some exemplary calculations to investigate this assumption (2). As demonstrated hereafter it is possible to substantiate the idea of a gravitation based strong force by using equations which were presented in the previous section.

A Compton particle's equatorial ring velocity is light speed c and it would be sensible if the tangential vortex velocity v_{tc} (equation 3.90) also predicts that speed at the Compton radius, i.e. when $d = r_c$, to have a physically sensible situation without a discontinuity in the equatorial plane. This thinking also applies to acceleration: ideally the gravitational acceleration a_g (equation 3.74) should match with the Compton acceleration a_c (equation 2.51) at $d = r_c$. Unfortunately, both equalities are not met using the respective equations. In case of an extreme Kerr black hole the situation is different, though: $v_{tk}(d = r_k) = c$ (equation 3.94) and $a_{gk}(d = r_k) = a_c(r_c = r_k) = c^2/r_k$ (equations 3.96 & 2.51). These circumstances bring up the idea that the v_{tk} velocity profile should be used for gravitational force in close proximity to a Compton particle's surface instead of v_{tc} as this removes the discontinuity. Adapting equation 3.86 accordingly results in the following force equation (for the described scenario r_{kM} is replaced by r_{cM}):

$$F_{cs} = r_{cM} \frac{mc^2}{d^2} = \frac{r_{cM}}{r_{cm}} \frac{c\hbar}{d^2} \tag{3.98}$$

The same result can also be obtained by replacing M in equation 3.86 with the extreme Kerr black hole mass equation 3.13. For Compton particles with equal radius the last equation simply reduces to $c\hbar/d^2$ - a result which matches with equation 3.66 and demonstrates the desired seamless force transition.

Using equation 3.98 for the exemplary case of two protons with mass m_p which are bound together like in an atom, and thus separated by a distance d of $2r_{cp}$, gives the following attractive force:

$$F_{cs_{ppa}} = r_{cp} \frac{m_p c^2}{(2r_{cp})^2} = \frac{1}{4} \frac{m_p c^2}{r_{cp}} = \frac{c\hbar}{4r_{cp}^2} = 178\,699\,\mathrm{N} \tag{3.99}$$

Using the common Newtonian gravitational force equation gives a much smaller force in contrast:

$$F_{g_{ppa}} = G\frac{m_p^2}{(2r_{cp})^2} = 1.055\,39 \times 10^{-33}\ \mathrm{N} \tag{3.100}$$

Comparing the results of these two force calculations gives:

$$\frac{F_{cs_{ppa}}}{F_{g_{ppa}}} = 1.693\,21 \times 10^{38} \tag{3.101}$$

Remarkably, this result matches with the strong force to gravitational force strength ratio which is approximately 10^{38}. This indicates that the nuclear binding force, or strong force, is given by equation 3.98 and gravitational in nature like Haramein suspected. Expressed in more sophisticated language: what is called the strong force seems to be the near field behaviour of gravity. According to Verlinde there may also be a gravitational far field behaviour (7) where gravitational force becomes proportional to $1/d$.

Using a rearranged version of Newtonian gravitational force (equation 3.86) it is also possible to calculate the corresponding "mid field" mass for two equal masses attracted by a 179 kN force:

$$\sqrt{\frac{178\,699\ \mathrm{N} \times (2r_{cp})^2}{G}} = m_l = m_\hbar/\phi_h \tag{3.102}$$

Interestingly, this result is exactly one Planck mass and in analogy to the "shielded" Compton particle charge, a topic which was treated in section 2.6, the Planck mass might be regarded as the "shielded" Compton particle mass. Please note that using the same procedure that led to the result of equation 3.102 for other types of Compton particles will also give a result of one Planck mass. This correlation also matches with the gravitational potential energy equation 3.31 which utilizes the Planck mass m_l instead of normal rest mass.

Since the Compton particle model is applicable to baryons, e.g. protons, and leptons, e.g. electrons, an issue arises: the gravitation based strong force should also apply to leptons but then electrons would be able to form atoms which is implausible. For example, two electrons separated by $2r_{ce}$ should experience a repulsive electric force of only 0.000 387 N and an attractive strong force of 0.0530 N. This issue could be solved if the involved Compton particles experience an electric repulsion force at such short distances which is proportional to their shielded charge. Then the electric repulsion force evaluates to 0.0530 N and counterbalances the strong force. For protons at atomic distances the situation should be similar and in order to have a net attractive force within atoms neutrons are presumably required.
In conclusion it can be said that the "shielded" Compton particle quantities are probably representing "it is as if there were" relationships, i.e. at short distances it is as if there were a Planck mass from the standpoint of Newtonian gravity and from the standpoint of Coulomb's law it is as if there were a Planck charge. This new interpretation for "shielded" charge probably invalidates the notion of a central charge monopole and internal particle polarization for Compton particles. Subsequently the presumed electric self energy contribution, as stated in section 2.7, has to be reconsidered.

The gravitational strong force also provides a possible explanation for the proton radius discrepancy which was already mentioned in section 2.2. Calculating v_{tk} for the case of a proton at a distance d of $4r_{cp}$, which equals the conventional proton radius, gives a predicted tangential velocity of $0.5c$. This suggests that the proton radius, as obtained by experiments, could be the result of an averaging effect that is linked to co-spinning space around the proton. If the space around a spinning Compton particle is actually co-moving then it becomes difficult to measure a Compton particle's size since the moving space can be interpreted as being part of the Compton particle. Furthermore, the Compton particle model assumes that there is no difference between the "substance" of a Compton particle and the space around it as everything is composed of PSUs in the fundamental topology (see section 3.8).
For a distance of $16r_{cp}$ the presumed velocity of space is predicted to be $0.125c$ which shows that it already drops to smaller fractions of c within atomic distances. Moreover, it is assumed that as a gravitational source becomes "point like" with increasing distance the velocity profile should blend from v_{tk} into v_{tc} to give the common Newtonian gravity.

3.14 OUR UNIVERSE

Currently it is still disputed if our universe is finite or not and due to cosmological expansion there seems to be no possibility to observe our universe in its full extent even if it were finite. The cosmological expansion also creates an invisible and intangible boundary inside our universe where objects are moving away from our solar system with light speed c and objects outside of this boundary recede even faster. The radius associated with this boundary is called the Hubble radius and the corresponding spherical volume is called the Hubble sphere whereby the Hubble radius r_{uh} is calculated by using the Hubble constant $H_0 \cong 74.3\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$ which is the characteristic value for the current cosmological expansion.

$$r_{uh} \cong \frac{c}{H_0} = 1.25 \times 10^{26}\,\mathrm{m} \tag{3.103}$$

The recession velocity v_r inside the Hubble sphere is given by Hubble's law

$$v_r = H_0\, d \tag{3.104}$$

whereby d denotes the distance to the observer - earth in case of our local Hubble sphere. According to experiments the energy density of our observable universe is $9.9 \times 10^{-27}\,\mathrm{kg/m^3}$ as stated by NASA*. This energy density is close to the "critical density" that characterizes a so called flat universe and which is given by:

$$\rho_{uc} = \frac{3H_0^2}{8\pi G} = 1.04 \times 10^{-26}\,\mathrm{kg/m^3} \tag{3.105}$$

Using equation 3.103 & 3.105 the mass which is contained inside our local Hubble sphere can be estimated as already demonstrated by various researchers:

$$m_{uh} \cong \rho_{uc} \times 4\pi r_{uh}^3/3 = \frac{c^3}{2GH_0} = 8.38 \times 10^{52}\,\mathrm{kg} \tag{3.106}$$

This mass will be referred to as the Hubble mass from now on and an interesting congruence is obtained when calculating the average mass density of a Schwarzschild black hole whose size matches that of a Hubble sphere:

$$\rho_{us} = \frac{m_s(r_{uh})}{4\pi r_{uh}^3/3} = \frac{8.38 \times 10^{52}\,\mathrm{kg}}{8.08 \times 10^{78}\,\mathrm{m^3}} = 1.04 \times 10^{-26}\,\mathrm{kg/m^3} = \rho_{uc} \tag{3.107}$$

The equivalence of equation 3.105 and 3.107 suggests that our local Hubble sphere may qualify as Schwarzschild black hole, or that its mass is at least close to that of a Schwarzschild black hole. This also means that the entropy of our local Hubble sphere is nearly identical to the maximum possible entropy as given by the Bekenstein-Hawking entropy (equation 3.48) which implies that the holographic principle should apply to our local Hubble sphere.
Usually black holes are proclaimed as being extremely dense but with increasing size their predicted average mass density gets lower, which also questions the notion that black holes must contain a gravitational singularity as theorized by general relativity theory. Theoretically, we might live inside a black hole without noticing it and despite this circumstance the space inside our local Hubble sphere could still be mostly flat. This is more in line with the PSU topology as presented in section 3.8 which suggests that the structure of space is strictly euclidean instead of being curved.

Another characteristic energy of our universe is the so called vacuum energy, or zero point energy, whose estimated density is very different from the critical density - a discrepancy which is also known as the "vacuum catastrophe". Assuming that the vacuum has a PSU structure as presented in section 3.8 allows calculating the mass density of the vacuum as follows:

$$\rho_v = \frac{R_{oct}(r) \times m_l}{4\pi r^3/3} = \frac{1}{2}\frac{m_l}{l_l^3} = 2.577\,59 \times 10^{96}\,\mathrm{kg/m^3} \tag{3.108}$$

Expressing this result as an energy density instead of a mass density yields:

$$u_v = \rho_v\, c^2 = \frac{1}{2}\frac{m_l c^2}{l_l^3} = 2.316\,62 \times 10^{113}\,\mathrm{J/m^3} \tag{3.109}$$

This energy density is in line with quantum physical calculations which also estimate the vacuum energy density to $10^{113}\,\mathrm{J/m^3}$ and thus the proposed PSU topology provides a possible answer to the question why we do not experience this enormous energy: the vacuum energy density is constant throughout our universe and this energy is also bound in countless rotating PSUs.

If our local Hubble sphere qualifies as Schwarzschild black hole might this imply that our whole universe is actually an extreme Kerr black hole? Depending on how large our universe is, and where our local Hubble volume is situated in it, we might not notice our universe's rotation since the tangential velocity at our location might be very low. In this line of thinking dark energy is presumably linked to the rotational energy of our universe which could resolve the so called vacuum catastrophe since dark energy and vacuum energy would then relate to two different physical properties: vacuum energy denotes the energy contained in space itself whereas dark energy relates to the energy associated with all matter that is being dragged along by our

* http://map.gsfc.nasa.gov/universe/uni_matter.html

universe's rotation. This thesis gains some support from the ability to express the Hubble constant in terms of frequency:

$$H_0 \cong 74.3\,\mathrm{km\,s^{-1}\,Mpc^{-1}} = 2.41 \times 10^{-18}\,\mathrm{Hz} \cong (1+\sqrt{2}) \times 10^{-18}\,\mathrm{Hz} \tag{3.110}$$

Moreover, the expansion of our universe might then be explained by a decrease of our universe's rotation frequency which would have to expand in order to conserve angular momentum. Newly processed data suggests that the expansion of our universe is even accelerating (15) which implies that the presumed deceleration of our universe is currently increasing. Underlying to these changes might be an oscillation pattern in the angular frequency and angular acceleration of our universe which could eventually lead to trend reversal, i.e. a contracting universe.

Developing the rotating universe conjecture further leads to the idea that our universe could be embedded in another universe whereby our universe should appear as an extreme Kerr black hole in the enclosing universe according to the physics of this outer universe, which in turn suggests a possibly infinite fractal multiverse structure of universes within universes. In this conception the boundary of an universe is defined by its Kerr black hole horizon whose purpose should be comparable to a cellular membrane in biology, i.e. separating individual entities and regulating the interaction. This conjecture implicitly also contains the requirement that a form of gravity must exist in all universes.

One of the remaining big cosmological mysteries, namely dark matter, may have already been solved because according to Mills dark matter can be explained by interstellar clouds of hydrinos, which in turn are hydrogen atoms with their electron below the proclaimed ground state, i.e. with a fractional quantum number n. This property makes hydrinos unreactive and also gives them distinct spectral absorption lines (4) which might explain why hydrinos remained undetected.

3.15 COUPLING CONSTANTS

Force coupling constants denote the relative strength of the different fundamental forces and are commonly denoted by the greek letter α. Coupling constant calculations are usually done by dividing the potential energy associated with a force which two particles exert on each other by the energy of a hypothetical photon with wavelength $\lambda = c/f = 2\pi \times d$ whereby d denotes the separation between these two particles.

As already shown in section 2.6 the electromagnetic coupling constant, which is also called fine-structure constant or Sommerfeld constant, arises naturally when assuming a polarization effect inside Compton particles (see equation 2.40) and is given by:

$$\alpha = \frac{e^2}{4\pi\epsilon_0\, d} \Big/ \frac{ch}{2\pi d} = \frac{e^2}{q_l^2} = 0.00729735 = \frac{1}{137.036} \tag{3.111}$$

The gravitational coupling constant is usually calculated using the proton as reference particle:

$$\alpha_g = \frac{Gm_p^2}{d} \Big/ \frac{ch}{2\pi d} = \frac{Gm_p^2}{c\hbar} = 5.905\,956 \times 10^{-39} = \frac{1}{1.693\,206 \times 10^{38}} \tag{3.112}$$

Please note that the last equation's result equals the inverse result of equation 3.101 which fits with the fact that the strong force coupling factor α_s is usually cited in literature as $\cong 1$ for atomic distances and thus equation 3.101 equals α_s/α_g. Due to the intrinsic relationships of the Compton particle model there are also various other ways to calculate the gravitational coupling constant and as shown by Haramein in (2) the gravitational coupling constant can also be obtained from mass ratios or even from purely geometric considerations

$$\alpha_g = \frac{m_p^2}{m_l^2} = \phi_h(r = r_{cp})^2 \tag{3.113}$$

whereby the $\alpha_g = \phi_h(r = r_{cp})^2$ relationship is a consequence of $\phi_h(r = l_l) = 1$ and equation 3.6. Further means of expression for the gravitational coupling constant are

$$\alpha_g = \frac{{\omega_{cp}}^2}{\omega_l^2} = \frac{l_l^2}{{r_{cp}}^2} = \frac{m_l^2}{m_k(r_k = r_{cp})^2} = \frac{m_p}{m_k(r_k = r_{cp})} \tag{3.114}$$

whereby $m_k(r_k = r_{cp})$ denotes a proton's hypothetical black hole mass.

Besides the force coupling constants there seem to be other characteristic coupling factors which are related to fundamental geometry: the factor $\sqrt{2} = 1.414214...$ has already been encountered in numerous equations but there are also approximate $\sqrt{2\sqrt{2}} = 1.681793...$, $1+\sqrt{2} = 2.414214...$ and $2\sqrt{2} = 2.828427...$

appearances in other fundamental relationships. The pertained equations were 2.50, 3.19, 3.52, 3.53, 3.67, 3.71, 3.72, 3.110, 3.112 and more potential matches are listed hereafter:

$$\text{Proton mass: } m_p = 1.672\,622 \times 10^{-27}\,\text{kg} \quad \text{(deviation less than 0.6\%)} \tag{3.115}$$

$$\text{Electron Compton wl.: } \lambda_{ce} = 2\pi r_{ce} = 2.426\,31 \times 10^{-12}\,\text{m} \quad \text{(deviation close to 0.5\%)} \tag{3.116}$$

$$r_{ce}/\,l_l = 2.389\,261 \times 10^{22} \quad \text{(deviation less than 1.1\%)} \tag{3.117}$$

$$\alpha r_{ce} = 2.817\,94 \times 10^{-15}\,\text{m} \quad \text{(deviation less than 0.4\%)} \tag{3.118}$$

$$r_{cp}/\,\alpha = 2.881\,99 \times 10^{-14}\,\text{m} \quad \text{(deviation less than 1.9\%)} \tag{3.119}$$

$$\text{Proton ang. fr.: } \omega_{cp} = \frac{c}{r_{cp}} = \frac{2\pi c}{\lambda_{cp}} = 1.425\,486 \times 10^{24}\,\text{Hz} \quad \text{(deviation less than 0.8\%)} \tag{3.120}$$

Writing down the relationship between c and $\hbar$ also results in another unexplained $\sqrt{2}$ occurrence:

$$c = \frac{a_l}{\omega_l} \cong 2\hbar\sqrt{2} \times 10^{42}\,\text{m}\,\text{s}^{-2}/\,\text{J} \tag{3.121}$$

Since $\hbar = E_l\,t_l$ the scaling factor $2\sqrt{2} \times 10^{42}\,\text{m}\,\text{s}^{-2}/\,\text{J}$ also appears in the relationship of the Planck acceleration with the Planck energy

$$a_l = \frac{c^2}{l_l} = \frac{c}{t_l} \cong 2E_l\sqrt{2} \times 10^{42}\,\text{m}\,\text{s}^{-2}/\,\text{J} \tag{3.122}$$

whereby $t_l = l_l/c = 1/w_l$ denotes the Planck time. Please note that the factor 10^{42} has already puzzled physicists of the early 20th century in what is known as Dirac's large number hypothesis. Moreover, the energy relationship of equation 3.122 also extends to the domain of temperature and it is linked to the $\sqrt{2}$ appearance in equation 3.67.

$$E_l \cong \frac{a_l}{2\sqrt{2} \times 10^{42}\,\text{m}\,\text{s}^{-2}/\text{J}} \cong k_b\sqrt{2} \times 10^{32}\,\text{K} \tag{3.123}$$

The key to understanding all these numerological mysteries presumably lies in the fractal PSU topology as presented in section 3.8 and rearranging as well as expanding equation 3.121 reveals a possible connection:

$$\begin{aligned} \frac{c}{h} &\cong \frac{2\sqrt{2}}{2\pi} \times 10^{42}\,\text{m}\,\text{s}^{-2}/\,\text{J} \\ &\cong \frac{\sqrt{2}l_l}{\pi l_l} \times 10^{42}\,\text{m}\,\text{s}^{-2}/\,\text{J} \\ &\cong \frac{\text{octahedron side length}}{\text{half PSU circumference}} \times 10^{42}\,\text{m}\,\text{s}^{-2}/\,\text{J} \end{aligned} \tag{3.124}$$

The last equation, which has a deviation of less than 0.51%, shows that the linear motion constant c and the rotational motion constant h are potentially related by the geometric properties of the PSU topology which in turn could be the cause of the various $\sqrt{2}$ appearances.

Square roots in general are also a property of the fractal PSU topology. As Burkard Polster explains, who is known as the Mathologer on YouTube, an equilateral fractal triangle of side length $4a$ consists of 16 equilaterial sub-triangles of sidelength a. This fractal relationship can also be visualized using the PSU topology which was presented in section 3.8:

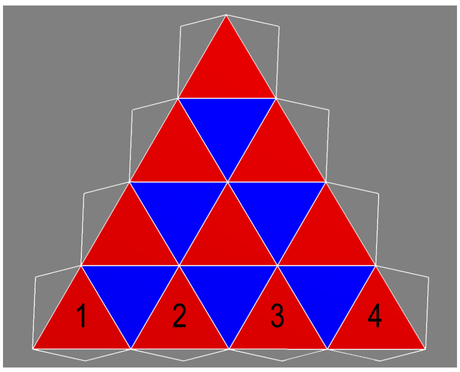

Figure 19: Fractal triangle

Generalizing this relationship and adapting it for the PSU topology shows that a triangle side length of $k\sqrt{2}l_l$ corresponds to the following total sub-triangle count:

$$n_{tri} = \left(\frac{k\sqrt{2}l_l}{\sqrt{2}l_l}\right)^2 = k^2 \tag{3.125}$$

Consequently the number of sub-triangles k which are adjacent to a triangle edge equals $\sqrt{n_{tri}}$. For the simple case of $n_{tri} = 4$, which corresponds to three red triangles (each one an octahedron face) and one enclosed blue triangle (one tetrahedron face) in figure 19, the number of sub-triangles on the triangle edge is $k = \sqrt{4} = 2$. This demonstrates that the square root is a scaling feature which is intrinsic to the fractal PSU topology.

3.16 UNCERTAINTY

A side effect of the PSU topology of space, as presented in section 3.8, is an inherent uncertainty in position since space is granular and therefore not infinitely divisible. This implies that even straight motions are jittery unless they are exactly along an octahedron edge or along the direction of an inner diagonal. In any case, the shortest measurable distance along an arbitrary coordinate axis cannot be smaller than a Planck length and denoting the uncertainty in position by δx leads to the following definition:

$$\delta x \geqq l_l \tag{3.126}$$

There is also another source of uncertainty that arises from PSU configuration changes which presumably happen in quantized intervals every $t_l = l_l/c = 5.391\,160 \times 10^{-44}$ seconds whereby t_l denotes the Planck time. Please note that in a thorough theory of quantum physics everything has to be quantized - even time. Consequently, our universe must be "frozen" between individual Planck time intervals but since physics usually treats time as continuous the Planck time freeze introduces a temporary deviation from mathematical calculations. This effect must also be regarded as a quantum physical uncertainty and thus the uncertainty in time, which is denoted here as δt, is given by:

$$\delta t \geqq t_l \tag{3.127}$$

A single PSU position change has the following properties: a PSU "jumps" a distance l_l during a Planck time interval t_l. Consequently such a jump happens with a speed of $l_l/t_l = c$ which corresponds to a kinetic jump energy of $E_j = m_l c^2/2$ as well as a jump momentum of $p_j = m_l c$ and multiplying these quantities with the aforementioned quantum uncertainties should lead to further granularity related uncertainties. According to this notion the quantum physical uncertainty relation for position and momentum is given by

$$\delta x\, p_j \geqq l_l\, m_l\, c = l_l \frac{\hbar}{l_l c} c = \hbar \tag{3.128}$$

whereby equation 2.12 is used to substitute m_l. The obtained result seems to be sensible although it is not in full agreement with contemporary quantum physics which states an value of $\hbar/2$ for the uncertainty relation of position and momentum.

Calculating the uncertainty relation for energy and time by using the same approach gives:

$$\delta t\, E_j \geqq \frac{1}{2} m_l\, c^2\, t_l = \frac{1}{2} \frac{\hbar}{l_l c} c^2 \frac{l_l}{c} = \frac{\hbar}{2} \tag{3.129}$$

This result is in agreement with contemporary quantum physics which suggests that the used approach is indeed sensible. Please note that equation 3.128 and 3.129 were derived specifically for PSUs, but the expectation is that these equations define an universal uncertainty limit which also holds true for Compton particles. This assumption is supported by the results of section 3.13 which suggest that the "shielded" mass of a Compton particle is also one Planck mass.

4 QUANTUM ELECTROMAGNETISM

A new perspective on fundamental particles and gravity was presented in the previous sections which subsequently requires that electromagnetism is reconsidered too. Therefore Maxwell's electromagnetism equations, which represent a macroscopic abstraction, also need a quantum physical description that fits naturally with the previously presented material. Especially the PSU should play a prominent role in such a description of electromagnetism since it is the presumed fundamental charge element in our universe and the following sections are presenting the first steps towards a PSU based description of electromagnetism.

4.1 FORCE UNIFICATION

Before treating the basic equations of electromagnetism it is demonstrated here that electromagnetic force and gravitational force can be united naturally when examining them at the PSU level. The magnitude of gravitational force between two PSUs at a distance d is given by:

$$Gm_l^2 \frac{1}{d^2} \tag{4.1}$$

Please note that a single PSU is not expected to create a frame dragging/vortex effect in its vicinity like a Compton particle. The magnitude of electrostatic force between two PSUs is given by:

$$\frac{|q_l|^2}{4\pi\epsilon_0} \frac{1}{d^2} \tag{4.2}$$

The last two force equations are actually equal in strength and multiplying them by d^2 results in the same constant expression:

$$Gm_l^2 = \frac{|q_l|^2}{4\pi\epsilon_0} = c\hbar = 3.161\,527 \times 10^{-26}\,\mathrm{N\,m^2} \approxeq \pi \times 10^{-26}\,\mathrm{N\,m^2} \tag{4.3}$$

This force equality is characterized by the $c\hbar$ term which will be referred to as the fundamental force gauge from now on. Please note that the $c\hbar$ term appears in the Schrödinger equation 2.60 and the presented fundamental force equations 3.28, 3.98, 4.11, 4.20 after reformulating them as well as in the Compton energy equation 2.48. The presence of c and h in all these equations makes sense because they are the fundamental constants for linear and rotational motion respectively. Interestingly, equation 4.3 also contains an approximate π relationship, with a deviation of less than 0.64%, which may or may not be a coincidence. Physicists have long wondered why gravity is weak, compared to other fundamental forces, but equation 4.3 demonstrates that it isn't weak at the PSU level and section 3.13 has also shown that gravity is getting stronger at short distances as it transforms into the strong force. Contemporary physics tries to unify the fundamental forces by using high temperature conditions but this approach may not be expedient in case a PSU constitutes the fundamental gauge "particle".

The fundamental force gauge term $c\hbar$ is also present in the definition of the Planck force, as shown by the following equation,

$$F_l = c\hbar/l_l^2 = m_l c^2/\, l_l = m_l a_l = c^4/\, G \tag{4.4}$$

besides a l_l^2 term which presumably is linked to entropy and information (see also equation 3.30, 3.37, 3.63, 4.13 and 4.21). Please note that the Planck force is not a force limit as it neither defines the smallest nor largest possible force in our universe. The Planck acceleration, though, should be the maximum possible translational acceleration because it denotes acceleration from rest to light speed c over a distance of one Planck length l_l during one fundamental Planck time interval $t_l = l_l/c$ as demonstrated by the following equation:

$$a_l = \frac{\Delta v}{\Delta t} = \frac{c - 0\,\mathrm{m/s}}{t_l} = \frac{c^2}{l_l} = 5.560\,816 \times 10^{51}\,\mathrm{m/s^2} \tag{4.5}$$

A faster configuration change is presumably not possible and the Planck acceleration incidentally also defines the largest possible centripetal acceleration because $v_t^2/d = c^2/l_l$.

Translational acceleration slower than the Planck acceleration can be stated as

$$\frac{j}{n} a_l = \frac{j}{n} \frac{c^2}{l_l} \quad \text{(with } j \leqq n\text{)} \tag{4.6}$$

whereby j denotes the number of quantum position jumps in the last n Planck time intervals. Please note that the last equation implies that every acceleration should be proportional to c^2 and in fact gravitational, electrostatic as well as magnetic acceleration can all be rearranged to exhibit a c^2 term (see equation 3.27, 4.12 & 4.23). The c^2 term also propagates to force and energy equations as can be shown by calculating the work required for moving a particle with constant force F over a distance $d = j \times l_l$:

$$E_{work} = F \times d = m \frac{j}{n} \frac{c^2}{l_l} \times j\, l_l = \frac{j^2}{n} mc^2 \tag{4.7}$$

The same argument can probably be made for rotational energy and in accordance with this presumption the Compton acceleration a_c exhibits a c^2 term as does the Planck acceleration a_l. Please note that the Compton acceleration relationship with c^2 also leads to the appearance of c^2 in the famous mass energy equation $E = mc^2$. Rearranging equation 2.51 and using equation 3.7 demonstrates this relationship:

$$E_c = a_c \frac{\hbar}{c} = \frac{c^2}{r_c} \frac{\hbar}{c} = mc^2 \tag{4.8}$$

4.2 COULOMB'S LAW

Coulomb's electrostatic force law is usually expressed as

$$F_e = ma_e = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{d^2} \tag{4.9}$$

but to be more aligned with the PSU concept Coulomb's law should be expressed in a form that directly utilizes PSU quantities. This goal can be achieved by reformulating the vacuum permittivity ϵ_0 using equation 2.40 to express ϵ_0 in terms of other fundamental constants

$$\epsilon_0 = \frac{1}{4\pi}\frac{q_l^2}{c\hbar} = \frac{1}{4\pi}\frac{e^2}{c\hbar\alpha} \tag{4.10}$$

which in turn allows writing Coulomb's law in the following form:

$$F_e = ma_e = \frac{c\hbar}{d^2}\frac{q_1 q_2}{q_l^2} = \frac{c\hbar}{d^2}\frac{\alpha q_1 q_2}{e^2} \tag{4.11}$$

Physics literature usually doesn't state the Coulomb force in that way but this expression is more sensible in the PSU context and physically more revealing. In particular because equation 4.11 uses fundamental charge terms and the $c\hbar$ term which is the fundamental force gauge (see equation 4.3). Moreover, equation 4.11 exhibits a noteworthy structural similarity with the gravitational force as stated in equation 3.28 (*note: see also appendix A*).

For the special case of two Compton particles, which both have fundamental charge e, the associated electrostatic acceleration can be reduced to a mass and charge independent equation. Using equation 3.7 to substitute mass m in equation 4.11 with its corresponding Compton radius r_{cm} and subsequent rearranging then gives the following Compton particle specific electrostatic acceleration:

$$a_{ecc} = \frac{r_{cm}c^2\alpha}{d^2} = \frac{\lambda_{cm}c^2\alpha}{2\pi d^2} = \alpha r_{cm}\omega_d^2 \tag{4.12}$$

Here the c^2 proportionality factor for fundamental acceleration appears again which was already discussed in section 4.1.

Expressing the electrostatic force in terms of the Planck force F_l is also interesting since then all fractions reduce to dimensionless scaling factors when grouping all terms according to their physical unit:

$$\frac{F_e}{F_l} = \frac{1}{d^2/l_l^2}\frac{q_1 q_2}{q_l^2} = \frac{1}{d^2/l_l^2}\frac{\alpha q_1 q_2}{e^2} = \frac{\check{q}_1\check{q}_2}{\check{d}^2} \tag{4.13}$$

Please note that this expression of electrostatic force has structural similarity with the gravitational force as stated in equation 3.30. See also section 3.5 for a discussion about the reasonableness of expressing force equations in this way.

4.3 ELECTRIC POTENTIAL ENERGY

Equation 2.41 already showed that electrostatic potential energy can be expressed as hf term and this understanding is generalized here whereby the used calculation approach is similar to the gravitational potential energy case (see section 3.6).

Substituting ϵ_0 in equation 2.36 by using equation 2.40 and furthermore substituting distance d with the angular frequency $\omega_d = c/d = 2\pi f_d$ (equation 3.34) allows expressing electrostatic potential energy in terms of frequency and charge:

$$U_e = -\hbar\omega_d\frac{\alpha q_1 q_2}{e^2} = -hf_d\frac{\alpha q_1 q_2}{e^2} = -hf_d\frac{q_1 q_2}{q_l^2} \tag{4.14}$$

For two Compton particles with charge e the last equation reduces to the astoundingly simple expression:

$$U_{ecc} = -\hbar\omega_d\frac{e^2}{q_l^2} = -\alpha\hbar\omega_d = -\alpha hf_d \tag{4.15}$$

It is remarkable that hf terms are applicable to photon energy, Compton particle energy, gravitational potential energy as well as electrostatic potential energy. This correlation highlights that the hf term has an universal meaning in our universe and that understanding physics in terms of frequency leads to new insights.

4.4 BIOT SAVART LAW

Before examining magnetic force in the PSU context the Biot Savart law has to be treated which is usually stated as

$$\mathbf{dB} = \frac{\mu_0}{4\pi}\frac{I\,\mathbf{ds}\times\hat{\mathbf{r}}}{d^2} \tag{4.16}$$

whereby μ_0 denotes the magnetic constant, d**s** is a short segment carrying current I and d**B** is the magnetic field caused by the electric current in d**s**. The variable d denotes the distance to the position of the current segment for a given point in space and $\hat{\mathbf{r}}$ is the normalized displacement vector of that point to the segment's position.

Using the relationship $c^2 = 1/(\epsilon_0\mu_0)$ and equation 4.10 it is possible to express μ_0 in terms of other fundamental constants:

$$\mu_0 = \frac{1}{\epsilon_0 c^2} = 4\pi\frac{c\hbar}{(q_l c)^2} = 4\pi\frac{c\hbar\alpha}{(ec)^2} \tag{4.17}$$

The last equation then allows writing the Biot Savart law without reference to μ_0:

$$\mathbf{dB} = \frac{c\hbar}{d^2}\frac{I\,\mathbf{ds}\times\hat{\mathbf{r}}}{(q_l c)^2} = \frac{c\hbar}{d^2}\frac{\alpha I\,\mathbf{ds}\times\hat{\mathbf{r}}}{(ec)^2} \tag{4.18}$$

Please note that the $c\hbar$ term appears again here which is the fundamental force gauge as explained in section 4.1.

4.5 LORENTZ FORCE LAW

The magnetic part of the Lorentz force law is given by

$$\mathbf{F}_m = m\,\mathbf{a}_m = q\,\mathbf{v}\times\mathbf{B} \tag{4.19}$$

for a particle with charge q and mass m moving with velocity **v** through a magnetic field **B**. Combining the magnetic part of the Lorentz force law with the Biot Savart law gives an expression for (differential) magnetic force which is more aligned with the force equation 3.28 and 4.11 than the commonly used expressions.

$$\mathbf{dF}_m = m\,\mathbf{da}_m = \frac{c\hbar}{d^2}\frac{Iq\,\mathbf{v}\times(\mathbf{ds}\times\hat{\mathbf{r}})}{(q_l c)^2} = \frac{c\hbar}{d^2}\frac{\alpha Iq\,\mathbf{v}\times(\mathbf{ds}\times\hat{\mathbf{r}})}{(ec)^2} \tag{4.20}$$

Please note that the fraction containing current I is a scaling term without dimensions.

Expressing the last equation with reference to the Planck force gives the following equation

$$\frac{\mathbf{dF}_m}{F_l} = \frac{1}{d^2/\,l_l^2}\frac{Iq\,\mathbf{v}\times(\mathbf{ds}\times\hat{\mathbf{r}})}{(q_l c)^2} = \frac{1}{d^2/\,l_l^2}\frac{\alpha Iq\,\mathbf{v}\times(\mathbf{ds}\times\hat{\mathbf{r}})}{(ec)^2} \tag{4.21}$$

in which every listed fraction is dimensionless and normalized with respect to the appropriate Planck unit(s). Other equations of similar form but for different forces are equation 3.30 and 4.13.

Like in case of Coulomb's force law the magnetic Compton particle acceleration can be examined as a special case. Applying equation 4.20 to a Compton particle with charge $q = e$, using $I = \delta q/\delta t = ne/\delta t$, substituting mass m by radius r_{cm} using equation 3.7 and finally rearranging for $\mathbf{a}_m$ gives the following magnetic acceleration for a Compton particle:

$$\mathbf{da}_{mc} = \frac{r_{cm} n\alpha}{d^2\,\delta t}\mathbf{v}\times(\mathbf{ds}\times\hat{\mathbf{r}}) \tag{4.22}$$

Assuming that the electric current is generated by a single Compton particle ($n = 1$) that travels with light speed through a Planck length current segment ($\delta t = l_l/c$, ds $= l_l$) and assuming furthermore that the accelerated Compton particle already moves with light speed ($v = c$), whereby all involved vectors are also orthogonal, the last equation results in an upper limit for the magnetic acceleration of a Compton particle:

$$a_{mc_{max}} = \frac{r_{cm}c^2\alpha}{d^2} = \frac{\lambda_{cm}c^2\alpha}{2\pi d^2} = \alpha r_{cm}\omega_d^2 = a_{ecc} \tag{4.23}$$

Interestingly, the last equation's result is equal to the electrostatic acceleration as given by equation 4.12 which makes sense since electric and magnetic force are different aspects of the electromagnetic force. It is remarkable that this equality followed from adapting fundamental equations for electric and magnetic force to the Planck units although relativistic effects were not considered yet. Moreover, the c^2 acceleration factor appears again in the last equation, which is expected for acceleration caused by a fundamental force as explained in section 4.1.

4.6 ELECTRIC & MAGNETIC FIELD

After expressing some of the fundamental electromagnetism equations in a way that is more suited for the dipole / PSU lattice view of quantum physics the question remains how electromagnetic fields are structured in space-time. Thieme provided some suggestions on that question in his book (1) and this section is based on these suggestions.

In the PSU context macroscopic electrostatic fields might be explained by grouping PSUs into dipoles and assuming that charged Compton particles polarize the space around them as shown schematically in the following picture.

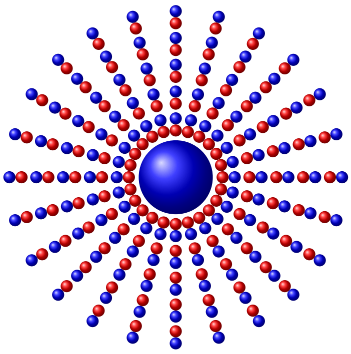

Figure 20: Dipole polarization in space

With increasing distance from a polarization source the average dipole orientation alignment in a particular volume is expected to decrease. Regions with similar overall dipole orientation alignment can be conceived as spherical shells in three dimensional space, which matches the electrostatic field symmetry expected from a single charged Compton particle that is stationary. When two charged Compton particles come close enough to each other their dipole patterns start to interact and the resultant net effect should match with the superposition of their macroscopic electric fields. That dipole pattern alteration in space is furthermore expected to cause a back reaction on these two charged Compton particles and this mechanism presumably embodies the macroscopic electrostatic force. Please note that in this view the (macroscopic) electric field is an (abstract) effect of the polarization behaviour of space with its positive & negative charged PSUs, and not vice versa, which implies that the electric field is not an independent physical entity in its own right. The same can be said about the magnetic field as shown in the next paragraph.

A magnetic field is presumably created by moving charges that cause an oscillatory movement of the individual dipoles in space. The following diagrams illustrate two consecutive moments of dipole oscillation whereby this oscillation is caused by a straight current of negatively charged electrons.

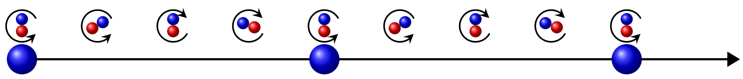

Figure 21: Dipole orientation oscillation

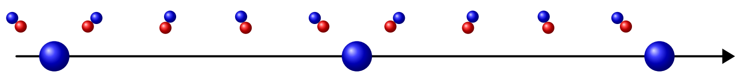

Figure 22: Subsequent dipole orientation

The dipole oscillation frequency depends on the speed of the moving electrons and the spacing between individual electrons whereas the oscillation amplitude depends on distance to the electric current vector and its electron density. In three dimensional space dipoles with identical phase can be conceived as rings around an electric current vector and rings of consecutive phase, i.e. with the same phase constant, will form notional tubes which have the cylindrical symmetry that is expected from a magnetic field around a straight current carrying wire. In case the electric current stops the dipole oscillation will also cease and the corresponding (abstract) macroscopic magnetic field subsequently vanishes too as expected from a magnetic field. When a charged Compton particle moves into a region of oscillating dipoles they will cause attractive and repulsive effects on the incoming Compton particle but these effects will not cancel out on average which causes a trajectory deflection on the incoming Compton particle and this mechanism presumably embodies the magnetic force. A stationary charged Compton particle, on the other, hand will not be affected by any oscillating dipoles around it because in that case the attractive and repulsive effects caused by the oscillating dipoles average out. A stationary charged particle is probably also displaced slightly due to nearby oscillating dipoles but still its mean position shouldn't change.

From what was professed here and in previous sections it could be possible to deduce a new quantum physical formalism of electromagnetism that is primarily based on fundamental geometry, elementary dipoles, Compton particles, Planck units and a vacuum structure as introduced in section 3.8. The acceleration of charged Comtpon particles as stated in equation 4.12 and 4.22 should be a natural outcome of such a new quantum physical formalism of electromagnetism. Please also note that the constants ϵ_0 (equation 4.10) and μ_0 (equation 4.17) have to be considered as emergent constants since they are defined in terms of other fundamental constants, whereby the occurrence of α in their definition is simply a consequence of the PSU's Planck charge being the appropriate charge gauge for electromagnetism. A discussion on how the presented quantum physical view on electromagnetism fits with special relativity theory is given in the next section.

Photons are not treated in this document because there are too many open questions about their nature. The expectation is, however, that photons are real particles, which are also composed of PSUs, so that they can possess momentum and have spin. The geometry and flow dynamics of photons should explain why they do not exhibit inertial mass but still interact with (entropic) gravity. Furthermore, photons should be able to align with each other and stick together to form electromagnetic waves. One geometry that might fulfil all these requirements is the torus and in analogy to the Compton particle spin derivation the photon's moment of inertia is expected to be that an infinitely thin loop (*see also appendix C*).

The entropic gravity notion together with quantum electromagnetism, as presented in this section, might also be the starting point for electro-gravitic physics. If gravity and electromagnetism indeed function by influencing the vacuum's PSU structure (see section 3.8) it could be possible to influence gravity by deliberate engineering of the PSU structure through electromagnetic fields.

5 DISCUSSION

The parameters chosen for the presented models may not be entirely correct yet and some of the presented ideas may also turn out to be wrong but overall the chosen approach seems to be promising. Many of the equations which were presented in this document may be regarded as simplifications of the true situation but nonetheless interesting and sensible results were obtained. Altogether, the presented relationships and results open up a new perspective on particle physics, quantum physics, gravity and electromagnetism. The stated particle radii will certainly be a point of critique but the fact that the proton radius as stated by contemporary physics (0.842 fm) is 4.00 times larger than the one calculated in this document suggests that the presented concepts are relevant since the proton radius deviation is not some weird factor.
This document treated quantum physics mostly in the original and literal sense, the physics of quanta, and it was demonstrated repeatedly that the fundamental quantities, e.g. for time, length, charge and mass, are defined by the Planck units. Moreover, the revealed symmetries between Planck Spherical Units (PSUs), Compton particles and black holes are remarkable and it would be surprising if they were all are meaningless.

Another deduction suggested by the presented material is that physicists should rather try to find concepts that incorporate dimensional reduction, to encode physical laws on the presumed holographic boundary layer of our universe, instead of aiming for higher dimensional models with 4 or even more dimensions. It was shown in this document that Compton particle spin, and partly also magnetic moment, can be calculated by using only two dimensional mathematics. Furthermore, the gravitational constant G can also be approximated as the effect of a two dimensional vortex. All these findings point towards the appropriateness of two dimensional physics at the fundamental level and even the big bang model of our universe should fit with the dimensional reduction idea because in case our universe can shrink again its holographic 2D surface would eventually vanish if our universe can compress itself back into a single PSU.

An important underlying assumption, which was not mentioned explicitly before, is that our universe has to be conceptual and axiomatic at the fundamental level in order to avoid circular reasoning and a senseless inflation of hypothesized particles, fields and dimensions. In accordance with this thinking it was proposed that the electromagnetic force is built on the concept of duality which is embodied on the physical level by the binary PSU charge. Please note that our whole reality would not exist without this fundamental duality since else Compton particles could not coalesce and consequently no atoms would form, which in turn are the basis for molecules and biological life. Probably due to the fractal nature of our universe the concept of duality, or opposites, is also reflected in all kinds of domains including human behaviour and philosophy. Gravitational force, on the other hand, is non-polar and purely attractive, or unifying in a more philosophical sense. It was proposed to emerge from thermodynamic and entropic considerations whereby entropy is rooted in the fundamental concepts of information theory. The proposed relationship between Compton temperature and particle size is also physically sensible as it reflects adiabatic behaviour, i.e. a Compton particle gets hotter when it contracts and cooler as it expands.

Surprisingly, it turned out that mass is not a fundamental quantity as it seems to emerge from the nature of Compton particles since if a Compton particle stopped spinning it would disintegrate and have zero mass according to the presented model. The previously mentioned proton radius discrepancy might also be explainable by Compton particle rotation since the movement of space, or more precisely the PSUs, around a Compton particle makes the experimental determination of its exact boundary ambiguous.
The constituents of a Compton particle, the PSUs, possess energy that is presumed to directly originate from their rotation. The equality between energy and rotation at the PSU level is thus defined as an axiom here, which in turn means that the (equivalent) PSU mass should better be conceived as condensed energy or locked up energy.
This line of thinking also implies that nothing in our universe could exist without rotation and subsequently it is sensible to increase the understanding of our universe in terms of frequency and hf energy terms. Charge, on the other hand, is a fundamental property because it cannot be explained in terms of something else and a PSU's charge can also only have two distinct values, i.e. positive or negative Planck charge.

Since gravitational and electromagnetic force have different conceptual causes it is likely not possible to unite their mathematical frameworks into one like it is possible with the electric and magnetic force, which can be united into the electromagnetic force. Nonetheless, it has been shown that gravitational and electromagnetic force are of equal strength at the PSU level which also constitutes a kind of unification. Another unification has been achieved with the strong force, which seems to be gravitational in nature, and according to this notion the strong force should be recognized as the near field behaviour of gravity.

Another realization is that the way our universe works is reminiscent of how computers create virtual realities. In this view the PSUs can be regarded as the voxels that make up our holographic universe, whereby a voxel is similar to a pixel but it refers to 3D space instead of 2D space. The computer memory analogue is the holographic information whereas the rules, e.g. fundamental forces, are the software. Moreover, the quantization of everything must also include time and using fixed time slices is the usual way for programming computer simulation or discrete control engineering. Thus our universe might be regarded as an ingenious technology that is far more advanced than we can fathom, whereby this statement does not imply that our universe is somehow "artificial" in the sense of being unnatural.

On many occasions the presented material enters into the territory of special relativity and general relativity theory, whereby not all of the statements made in this document are fully in line with these theories. To assess this topic further it is important to note that special relativity theory makes two assumptions about our universe: there is no preferred inertial frame and there is no network of synchronized clocks but both assumptions should be reconsidered according to the findings presented in this work. In particular the crystal like vacuum structure, as presented in section 3.8, constitutes a fundamental reference frame, although it might not be a perfect inertial frame in case our universe is spinning because space itself should then also be subjected to the associated acceleration. It was proposed that the crystalline structure of space is governed by octahedrons and there is a conceptual reason why space should be partitioned like this: octahedrons are the simplest possible geometry which encodes three dimensional euclidean space because an octagon's contours are composed of three orthogonal square planes as can be seen in figure 10 *(thanks to Constantin Böhm for pointing this out)*. The PSUs, on the other hand, constitute a network of synchronized clocks across space and it could make sense to interpret time in terms of PSU & Compton particle frequency, instead of an abstract dimension, as this notion provides a possible explanation for the unification of local time and local space into the so called space-time which exhibits relativistic effects. It was shown in section 2.5 that a Compton particle's relativistic Lorentz frequency f_γ increases as the particle moves faster, but a PSU's characteristic Planck frequency is fixed, and it may be their frequency ratio which is responsible for what special relativity theory calls time dilation in case this ratio influences a Compton particle's interactions and movements. The related effect of relativistic length contraction has already been linked to the relativistic Lorentz frequency in section 2.5 through the relativistic Compton particle radius. That section also made the suggestion that the Lorentz factor and relativistic particle energy could be intrinsic Compton particle properties, instead of being associated with an abstract inertial frame, which implicitly requires the existence of a preferred inertial frame, or set of frames, in which a Compton particles relativistic properties are satisfied. Moreover, the presented model of a quantized space-time presumes that Planck length l_l and Planck time t_l

are fundamental quantities which consequently implies that light speed $c = l_l/t_l$ should be regarded as an emergent quantity, i.e. light speed is simply the limit for position changes in the granular space-time of our universe.

The presented material on electromagnetism suggests that there is one absolute physical truth about electromagnetism in space-time which is given by its momentary PSU configuration. Special relativity theory instead builds heavily on the notion of tantamount frames but this abstract concept does not fit well with the granular space perspective and what really should matter is the local interaction of a charged Compton particle with its surrounding PSUs. Special relativity theory may provide many equivalent descriptions for a macroscopic electromagnetic force using other points/frames of reference, but many of these are irrelevant for the physical interaction in space and presumably predict pseudo-forces. These statements do not deny relativistic effects, length contraction and time dilation are real as proven in many experiments. The proposition made here is that relativistic effects are intrinsic to Compton particles, which presumably can change their physical properties, instead of transforming space or electromagnetic fields. Relativistic transformation of electromagnetic field components, as experienced by a charged particle which moves with high velocity, is another matter that must also be explainable in the context of the stated propositions. It is suggested here that this relativistic transformation might also be explainable by local interactions of a charged Compton particle with the PSU configuration in its surrounding space.

The relationship of the presented material with general relativity theory is complex to ascertain. Some of the presented work relies on the findings of general relativity theory, especially the black hole equations, and a potential explanation for the equivalence principle of general relativity is implicitly contained in section 2.5 & 3.9: relativistic inertial mass is presumably directly related to the relativistic Lorentz frequency f_γ, which in turn depends on the Compton frequency f_c and the relativistic de Broglie frequency $f_{b\gamma}$, whereas gravitational mass is implicitly related to f_γ via the relativistic Compton temperature that depends on a particle's surface area, which in turn is also governed by a particle's relativistic Lorentz frequency f_γ, and relativistic energy hf_γ. The proposed effect of these relationships is that the resistance against change in a Compton particle's relativistic Compton temperature is what causes inertia and its gravity directly depends on the said temperature, which physically links these two phenomena.
On the other hand, some of the material which was presented in this document opposes the notion of curved space which is central to general relativity theory. In particular Newtonian gravity was obtained by an entropic gravity model, the structure of space was proposed to be crystal like as well as euclidean and even the gravitational constant G has been classified as emergent constant. In any case though, there needs to be a physical link between the presented material and general relativity theory. This indispensable link seems to be the $8\pi G/c^4$ term in the Einstein field equations as it exhibits the following relationships:

- The term G/c^4 appears in Newtonian gravity when reformulating it in terms of energy or temperature (see equation 3.77).
- The Planck force can be expressed as c^4/G (see equation 4.4) and thus the term G/c^4 represents a link to the quantum level.
- The term $8\pi G/c^4$ is linked to the measure of information N (see equation 3.37) and η_{sq} (see equation 3.52) because it can be expressed as $4\pi(2l_l^2)/(c\hbar)$, whereby $2l_l^2$ represents the PSU square area as depicted in figure 7 and $c\hbar$ is the fundamental force gauge (see equation 4.3).

A highly speculative answer to the question what the fundamental nature of gravity is may be that what appears as curved three dimensional space is actually the effect of a two dimensional vortex on the holographic surface of our universe. Another very interesting proposal is provided by Ted Jacobson who suggests that the field equations of general relativity theory represent a thermodynamic state equation (13). The relationship of these field equations with the entropic gravity notion would then be analogous to the relationship of a sound wave equation with the molecules of air. According to Jacobson the Einstein field equations also depend on local thermal equilibrium and if that condition is violated general relativity theory presumably no longer provides an accurate description of gravity. In any case, it has become evident from the presented findings that entropic gravity constitutes the long sought link between gravity on small and cosmological scales, which also suggests that the entropic notion is more fundamental than the curved space view. This viewpoint also make the so called Higgs boson unnecessary for explaining gravitational force.

It has been shown in section 2.9 and 3.4 that sensible variants of the Schrödinger equation exist which contain key properties of the presented concepts, namely the Compton wavelength, Compton radius and black hole radius. This suggests that the presented models have merit and that they have a physical connection to the Schrödinger equation. The Schrödinger equation can also be related to entropy, as shown by Juho Leppäkangas in "An Information Theory Approach to Wave Mechanics" (17), which constitutes a link to the entropic gravity notion that, in combination with the granularity of space-time, may eventually lead to a resolution of conflicts between quantum physics and models of gravity.

In the context of hydrogen the Schrödinger equation seems to conceal the real physics as proposed by Randell Mills who has developed a compelling alternative equation which predicts the same energy levels and is connected to the Schrödinger equation via a Fourier transformation (4). There is evidence to believe that Mills is on the right track as he can calculate molecular bonding energies to a high degree of precision on normal computers with his software Millsian, which is an extraordinary achievement. Moreover, he predicted a new form of hydrogen with fractional orbital number n, i.e. $1/2, 1/3, ..., 1/137$, which Mills termed hydrino and he is already actively developing hydrogen based energy generation technology based on this insight at his company Brilliant Light Power. According to Mills a cornerstone experiment of quantum physics, the Stern-Gerlach experiment, is also explainable by using his model and the well established Maxwell equations of electromagnetism (4). Earlier attempts to find a classical explanation for the Stern-Gerlach experiment presumably failed because it was not conceived that the surface of a fundamental particle could have a complex and dynamic electromagnetic structure.

In conclusion, it seems that the Schrödinger equation mixes distinct phenomena together that have different physical causes which in turn makes this equation incomprehensible and mysterious. This suggests that the Schrödinger equation should be dissected into several concepts and equations which are physically more revealing on their own.

Another important quantum physical phenomena, entanglement, might become explainable by further advances in holographic physics. Two possible mechanisms come to mind: interference, in case holographic information is somehow encoded via frequencies, or redundant bits of information. The latter proposal qualifies as a so called "hidden variable" theory but such theories are unfortunately expected to be non compliant with Bell's quantum inequality, unless there is some yet undiscovered loophole which might exist in holographic physics.

Reflecting on the fundamentals of our universe also leads to an important philosophical insight: thinking that science can explain the mystery of existence is actually a fallacy. Ultimately our universe arose from something we cannot fathom and unavoidably at some point the workings and properties of our universe cannot be explained any further from within our universe. Please note that this conclusion cannot be avoided by postulating further fields, particles or dimensions. Moreover, the proposed systematic behaviour at the quantum layer and its degree of organization should be considered as engineering masterpiece that cannot be the result of chance and chaos. Thus it is only logical to assume that there must be a creator of some kind - even from the scientific perspective. On the human level this is reflected by the tendency of many humans to instinctively believe in a creator god although organized religion has also been a source of spiritual abuse. Despite this there might be some wisdom in the various spiritual traditions that is linked to what was presented in this document. For example, the taoistic Yin and Yang is a reflection of the fundamental polarity that physics calls charge and the hermetic teaching "as above so below" can be understood as an allegory to a fractal universe. Interestingly, some influential ancient high cultures were obsessed with pyramids which are halved octahedrons. This begs the question if these cultures built pyramids because a pyramid is a basic geometric form or did they consider this geometry to be sacred? The triangle, which is an important component of the presented concepts, is also found in several spiritual traditions. Hinduistic tradition, for example, states that the Kundalini energy is located in the sacrum bone which resembles a triangular shape. Moreover, Hinduism has a concept called trimurti and triangles also appear in Hindu iconography. Christians, on the other hand, believe in the holy trinity which is often depicted as a triangle in paintings. Interestingly, some meticulous translators of religious texts think that god described himself to Moses as "I will become what I choose to become" in book Exodus (3:14) and as possessing "dynamic energy" in book Isaiah (40:26) which are peculiar wordings that may actually be related to physics. Furthermore, the gospel of John states that "in the beginning there was the word" and the Hindu tradition worships the syllable OM as the sacred primordial sound of creation. These statements may very well be allegories for vibration or oscillation expressed in words appropriate for the time they were initially written down and the reference to a primordial word in the gospel of John also implies a deliberate creation act as words imply consciousness. Unfortunately, our modern society exhibits a big division between physics, philosophy and spirituality which should be reconciled since all of these disciplines ultimately try to decipher the same mystery and have the duty to help humans grow.

The presented material is also a pledge to move away from extreme reductionist thinking. Reductionism certainly was necessary for scientific progress in the recent centuries, but we may have reached a point where more integrated and systemic thinking is necessary to make further scientific advances. In particular, it is questionable if building ever more powerful particle accelerators will really lead to breakthroughs in physics since smashing particles apart which presumably possess complex dynamics probably leads to a limited or wrong understanding of their intrinsic workings.

6 CONCLUSIONS

The material presented in this paper has demonstrated that the work of Horst Thieme, Nassim Haramein, Randell Mills as well as Erik Verlinde can be combined and extended into a novel holo-fractal quantum physical perspective on our universe.

Holographic, because on one hand the Bekenstein-Hawking entropy, which is the prime characteristic of the holographic principle, is governing the self energy of Compton particles as well as black holes (see section 3.9) and, on the other hand, several fundamental quantities of particle physics can be described by two dimensional equations which hints towards an underlying two dimensional description of reality that might be encoded on a holographic surface. Section 3.7, 3.9 & 3.10 also presented evidence which suggests that gravity is actually entropic in nature and this view of gravity is conceptually a natural fit with the holographic principle since both concepts deal with information as well as entropy and are dependent on the respective surface area. Moreover, the energy contained in our local Hubble sphere is close to the corresponding Schwarzschild mass, as shown in section 3.14, which constitutes another connection to the holographic principle which was originally derived from black hole thermodynamics.

Fractal, because similar design principles can be found at different scales of our universe, in particular the concept of (spinning) spheres, whereby these principles express themselves mathematically in the holographic mass equations and the widespread applicability of hf terms in different branches of physics. Therefore objects of vastly different size, i.e. Planck Spherical Units (PSUs), Compton particles and black holes, have similar mass equations as shown in section 3.2, 3.3 & 3.5. As demonstrated in appendix A the inverse holographic mass equation is even implicitly contained in all fundamental force equations which again reflects the fractal nature of our universe. Extending the fractal sphere pattern further leads to the idea that our universe should also be a spinning sphere, a notion which was described in section 3.14. In addition to that biological life depends on eggs and cells which can be regarded as another expression of a fractal universe as every one of these entities constitutes its own biological universe in an approximately spherical container.

Quantum, because everything in our universe comes in chunks - even time and space whereby the latter presumably is a crystal like structure which is composed of PSUs as shown in section 3.5 & 3.8. The quantities of these chunks are defined by the Planck units, as demonstrated repeatedly throughout this document, and quantum uncertainty seems to be an effect of the granularity of space-time as shown in section 3.16. It has also been pointed out in section 2.9 and 3.4 that the cornerstone equation of quantum physics, the Schrödinger equation, contains key characteristics of the Compton particle model and black hole physics when expressing it in uncommon, but physically sensible, variants which suggests a strong link between these topics. In addition to that Leppäkangas provides a different interpretation of the Schrödinger equation in (17) which should not be in conflict with the Compton particle model and is rooted in entropy as well as quantum physical uncertainty. Moreover, it could be possible to model electromagnetic fields in a way which is consistent with the presented material and which also incorporates the PSUs as demonstrated in section 4.6.

The presented concepts also enabled several unifications: various fundamental particles were described by the Compton particle model (all of section 2), the very large and the very small were put in a common framework (section 3.2, 3.3 & 3.5), the strong force was ascribed to gravity (section 3.13) and electric as well as gravitational force were shown to be of equal strength at the PSU level (section 4.1). The Compton particle sections 2.3 and 2.4 showed that particle spin and magnetic moment can also be calculated by using classical mechanics, which was deemed impossible without quantum physics, when using the Compton radius and assuming that Compton particles have certain internal dynamics. Moreover, the Compton particle surface was shown to exhibit a temperature which is conceptually related to the temperature of a black hole horizon (section 3.10). This makes sense since our universe can be regarded as a giant thermal bath and consequently every object in it should exhibit a temperature. This notion also fits with the entropic gravity concept since it was shown that gravity can be regarded as a cooling process (section 3.11). In addition to that the content of section 2.10 suggests that the Compton particle model can also be extended to compound particles like hydrogen.

In general, the presented work suggests that our universe features incredible systematics and interconnectedness although it is seemingly governed by chance and chaos. Lots of open questions remain, and despite its length this paper still only touches all the various subjects on the surface, but the stated results and revealed relationships should be interesting enough to substantiate the presented thinking and encourage further research. Especially the role of entropy and information needs deeper assessment since they are underlying to all observable phenomena of our universe according to the presented material.

Acknowledgments

- Special thanks go to Haramein, Thieme and Mills for their life long efforts and courage to go beyond conventions.
  http://resonance.is, http://brilliantlightpower.com
- For mathematical calculations Andrey Ivashov's "SMath Studio" was used which greatly aided the development of this work.
  http://smath.com
- Images of platonic solids were created with "Great Stella" which is provided by Robert Webb.
  http://www.software3d.com

Appendix A FUNDAMENTAL FORCE EQUATIONS

Many fundamental force equations were presented throughout this document and the following table presents them together to demonstrate their structural similarity when appropriate normalization units are used, e.g. m_l, e and ec.

Force	General case	Compton particle case ($q = e$)	
Gravitational	$c\hbar/d^2 \; m_1 m_2/m_l^2$	$c\hbar/d^2 \; f_{c1} f_{c2}/f_l^2$	
Strong		$c\hbar/d^2$	(for equal particles)
Coulomb	$c\hbar/d^2 \; \alpha q_1 q_2/e^2$	$c\hbar/d^2 \; \alpha$	
Lorentz w. B.S. (ortho.)	$c\hbar/d^2 \; \alpha I q v/(ec)^2 \, \mathrm{d}s$	$c\hbar/d^2 \; \alpha n v/(c^2 \delta t) \, \mathrm{d}s$	(using $I = en/\delta t$)

Table 4: Equations of fundamental forces

The common term $c\hbar/d^2$ has some further noteworthy forms

$$\frac{c\hbar}{d^2} = \frac{F_l}{d^2/l_l^2} = \omega_d^2 \frac{\hbar}{c} = a_d \, m_d \tag{A.1}$$

whereby $\omega_d = c/d$, $a_d = a_c(r_c = d) = c^2/d$ and $m_d = m_\hbar(r_c = d) = \hbar/(c\,d)$. Whether the angular frequency term ω_d^2 has a real physical meaning is unclear and it can only be speculated if it might be related to holographic surface encoding. The implicit presence of the Compton acceleration a_c and inverse holographic mass $m_\hbar$ in equation A.1, however, is a remarkable recurrence of patterns/equations which were repeatedly identified as being fundamental for a fractal/self similar universe.

Appendix B MASS BRANCHES

The following figure illustrates the relationships of the holographic mass equations in order to provide a more intuitive understanding of them.

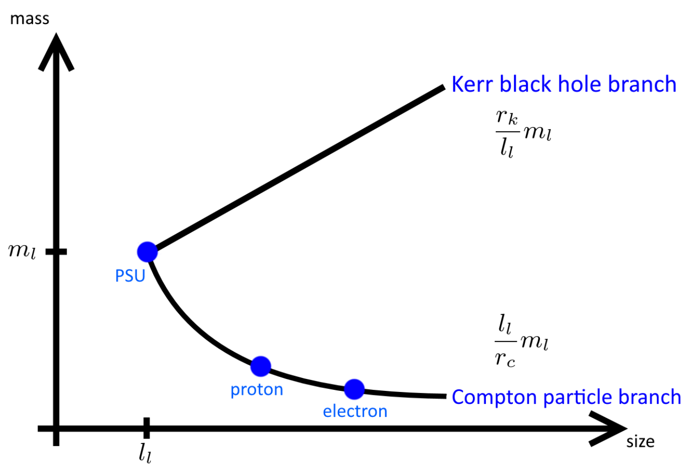

Figure 23: Mass branches

The last figure shows that the Planck Spherical Unit (PSU), with a radius of one Planck length and a mass of one Planck mass, qualifies as an extreme Kerr black hole as well as a Compton particle. Compton particles, e.g. protons and electrons, can be regarded as inflated PSUs which have a lower surface temperature than the PSU. Extreme Kerr black holes, on the other hand, which are primarily aggregates of Compton particles and photons, exhibit a noteworthy symmetry of their mass equation with the Compton particle mass equation, whereby this symmetry feature is also regarded here as evidence for the fractal universe notion.

Appendix C GEOMETRY OF MATTER PROPOSAL

This appendix section presents a proposal on how photons, Compton particles and hydrogen could be related geometrically.

A photon is presumably a rotating toroid which exhibits some kind of whirl pattern on its surface and is built from positively and negatively charged PSUs. This rotating toroid also acts as a superconducting circuit that creates a magnetic field in its surrounding space. Their magnetic field allows photons to align and attract each other in order to form larger electromagnetic waves which should solve the particle/wave duality issue for photons. The toroidal form also allows photons to exhibit linear momentum and the associated moment of inertia should be that of an infinitely thin ring.

Two photons can merge to form a Compton particle that is approximately spherical but retains the two toroid whirls of the original photons as shown in the following figure. The moment of inertia associated with this structure should be that of an infinitely thin disc.

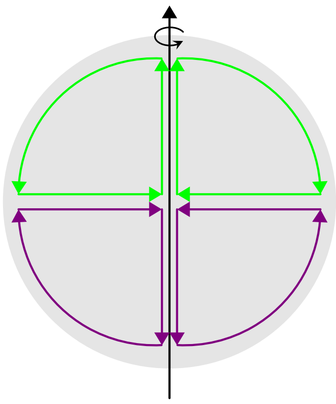

Figure 24: Compton particle with two toroids

Please note that the green and violet lines are inclined to the equatorial plane which cannot be visualized properly in this cross section view. The flow pattern proposed in this section does not match exactly with the one that is proposed by Mills, see section 2.3 and reference (4), but the patterns are similar.

An electron and a proton can merge via electromagnetic attraction to form the compound particle which is known as hydrogen. This process is probably guided by the involved magnetic moment vectors which should ensure the alignment of both spin axes. The proton will always end up in the centre of the much larger electron which encloses it completely (see section 2.10), somewhat similar to a peach and its pit.

References

[1] Thieme, Horst. (2012). Das entzauberte Elektron.
ISBN 978-3-943760-39-2

[2] Haramein, Nassim. (2013). Quantum Gravity and the Holographic Mass.
ISSN 2231-1815, Vol: 3, Issue: 4, page: 270-292
http://www.sciencedomain.org/abstract/1298#.UIR5alDXSLh

[3] Haramein et al. (2016). The electron and the holographic mass solution.
https://resonance.is/wp-content/uploads/EHM_30.pdf

[4] Mills, Randell. (2016). The grand unified theory of classical physics.
ISBN 978-0-9635171-5-9
https://brilliantlightpower.com/book-download-and-streaming/

[5] 't Hooft, Gerard. (1993). Dimensional Reduction in Quantum Gravity.
https://arxiv.org/abs/gr-qc/9310026

[6] Verlinde, Erik. (2010). On the Origin of Gravity and the Laws of Newton.
https://arxiv.org/abs/1001.0785

[7] Verlinde, Erik. (2016). Emergent Gravity and the Dark Universe.
https://arxiv.org/abs/1611.02269

[8] Brouwer et al. (2016). First test of Verlinde's theory of Emergent Gravity using Weak Gravitational Lensing measurements.
https://arxiv.org/abs/1612.03034

[9] Unruh, William. (1976). Notes on black-hole evaporation.
DOI 10.1103/PhysRevD.14.870
https://journals.aps.org/prd/abstract/10.1103/PhysRevD.14.870

[10] Kerr, Roy P. (1963). Gravitational Field of a Spinning Mass as an Example of Algebraically Special Metrics.
DOI 10.1103/PhysRevLett.11.237
https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.11.237

[11] Grumiller et al. (2014). Black holes and thermodynamics - The first half century.
https://arxiv.org/abs/1402.5127

[12] Fuller, Richard Buckminster (1982). Synergetics: Explorations in the Geometry of Thinking.
ISBN 978-0020653202

[13] Jacobson, Ted. (1995). Thermodynamics of Spacetime: The Einstein Equation of State.
DOI 10.1051/epn/2010101
https://arxiv.org/abs/gr-qc/9504004

[14] Couder et al. (2010). Walking droplets, a form of wave-particle duality at macroscopic scale?
DOI 10.1051/epn/2010101
https://www.europhysicsnews.org/articles/epn/abs/2010/01/epn20101p14/epn20101p14.html

[15] Various authors. (2019). A SHARP view of H0LiCOW: H0 from three time-delay gravitational lens systems with adaptive optics imaging.
Monthly Notices of the Royal Astronomical Society, Volume 490, Issue 2, December 2019, Pages 1743-1773, DOI 10.1093/mnras/stz2547
https://academic.oup.com/mnras/article/490/2/1743/5568378

[16] Haus, Hermann. (1986). On the radiation from point charges.
DOI 10.1119/1.14729
https://aapt.scitation.org/doi/10.1119/1.14729

[17] Leppäkangas, Juho. (2019). An Information Theory Approach to Wave Mechanics.
http://vixra.org/abs/1912.0063

[18] Thorne, Kip Stephen. (1974). Disk-Accretion onto a Black Hole. II. Evolution of the Hole
Astrophysical Journal, Vol. 191, pp. 507-520. DOI 10.1086/152991
https://ui.adsabs.harvard.edu/abs/1974ApJ...191..507T/abstract